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Editor

ROY WALDO MINER

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Editor

ROY WALDO MINER

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Executive Director: EUNICE THOMAS MINER

SECTION OF GEOLOGY AND MINERALOGY

GEOCHEMISTRY OF NATURALLY OCCURRING CARBONACEOUS SUBSTANCES*

By Irving A. Breger

United States Geological Survey, Washington, D. C.

It has been recognized for some time that naturally occurring carbonaceous substances may play important roles in weathering processes or in the geochemical cycles of certain elements. Interest in such processes has led to considerable publication with regard to the composition and physical properties of such organic substances, especially where the material may occur in sufficient quantities to be of industrial interest. The common approach, however, has been descriptive and has usually been based on ultimate commercial application. Geologists have speculated on the origin and nature of naturally occurring carbonaceous substances, but few definitive studies have been conducted, for the problems are difficult and of a more or less academic nature. Modern diagnostic and analytical techniques provide hope for the unambiguous solutions to many such problems.

One approach to the solution of problems in organic geochemistry is by a genetic route in which there must be considered three major factors: progenitors, depositional environment, and metamorphosis. An excellent example of this approach is the study of the origin of coal. Considering coals derived from woody plants, it is possible to examine the principal substances of woody tissues that could serve as the progenitors of coal. Such substances and their approximate percentages in wood are: cellulose, 70 to 80 per cent; lignin, 18 to 27 per cent; and waxes, resins, and proteins, 5 per cent.

Cellulose is the major constituent of woody plants. Cellulose, however, is readily and rapidly attacked, destroyed, or altered by a wide variety of fungi and aerobic or anaerobic bacteria. It is not known what proportion of the cellulose is converted to soluble and gaseous products and how much, if any, is transformed biochemically into other substances that may eventually enter into the coalification process.

Lignin, while it accounts for only about one fourth of the plant substance, is refractory and, while it undergoes certain biochemical changes, nevertheless tends in large part to survive the biochemical degradative process to which the wood is subjected. Lignin residues, together with some cellulose or cellulosic transformation products, therefore probably serve as the major progenitors for coal formation. These biochemical

* This paper, illustrated with lantern slides, was presented at a meeting of the Section on October 4, 1954. Publication has been authorized by the Director of the United States Geological Survey.

products, termed humic substances, produced and collected in a freshwater environment, form peat, lignite, and then, perhaps, subbituminous coal. Metamorphosis of the low-rank coal, commonly called the dynamochemical stage of coalification, leads to devolatilization of the humic substances with resultant increase in carbon content. High temperatures and high pressures have been considered as possible agencies for this transformation. The survival of certain functional groups in porphyrins associated with coal, however, provides negative evidence for unusually high temperatures in the coalification process. Although hydrostatic pressure seems to have little if any effect in the devolatilization of the coal substance, there is both geological and experimental evidence that shear stresses may be important in the coalification process.

Crude oil has similarly been studied from the genetic point of view. In this case a geological fence[1] has been established within which geochemical considerations must be confined. It has been established, for example, that petroleum is produced from marine organic sediments at relatively low temperatures. Although some investigators have considered the possibility that crude oil represents an accumulation of primary products,[2] most petroleum geologists are of the opinion that the many hydrocarbons found in crude oil were formed by the conversion and alteration of animal and vegetal remains, perhaps planktonic and algal in nature.[1]

In studies of marine bacteria, Stone and Zobell[3] have shown that certain organisms are able to produce small quantities of hydrocarbons during their metabolic processes. Radioactivity is another possible source of energy for the conversion of complex marine organic material into hydrocarbons. It has been shown experimentally that bombardment of certain compounds that occur in association with crude oils by alpha particles leads to the production of hydrocarbons.[4,5,6] The fluidity of crude oil, once it has been produced and expressed from its source bed, greatly complicates study of the origin of the material, for little is known regarding changes that may take place in the composition of the oil during its migration.

Coal and crude oil represent two major accumulations of naturally occurring carbonaceous substances, but there are many less pretentious occurrences that require consideration. Among such substances are tar sands, asphalts and asphaltic-type materials, kerogen, black shales, and carbonaceous pellets. Many of these substances are particularly important because they are associated with economically valuable quantities of such elements as copper, vanadium, or uranium.

Organic substances that can be dissolved or extracted by solvents can be studied by standard physical and chemical techniques such as chromatography, fractional distillation, infrared and ultraviolet absorption, or functional group analysis. A major problem is encountered,

however, when the material under study is found to be insoluble in any common solvent, and especially if it is intimately associated with large percentages of fine-grained mineral matter. Then physical and chemical methods of analysis lose their effectiveness and become less reliable because of the inorganic content of the material under investigation. The problem, therefore, becomes one of separating the organic and inorganic constituents by mechanical techniques that result only in minor changes, if any, in the chemical structure and composition of the organic material. Difficulties in attaining such separations have led, in the past, to the application of chemically destructive techniques, such as pyrolysis, in an effort to isolate the organic matter for characterization. Unfortunately, it is difficult to relate pyrolytic products, as an example, to the original organic substance and arrive at valid conclusions.

Difficulties inherent in the study of many organic materials, especially carbonaceous shales, have complicated the investigation of such substances from a genetic point of view. Lack of information, moreover, has made it difficult to distinguish between genetic and metamorphic relationships. As a consequence of the lack of data related to these substances, much of the published information is speculative in nature and there is a tendency to consider many soluble substances as petroleum residues or insoluble substances as polymerized petroleum residues.

One of the most frequently used classifications for carbonaceous materials is that suggested by Abraham.[7] Abraham's classification is dependent upon solubility properties and does not consider genetic relationships between various naturally occurring carbonaceous substances. Within recent years a number of investigators have made serious attempts to interrelate many naturally occurring carbonaceous substances on the basis of chemical composition or chemical structure. Work of this type has been carried out specifically for coal by Seyler[8] and van Krevelen,[9] the latter in an investigation of the chemical nature of coal and of the processes involved in its formation. Owen[10] and Eklund,[11] in somewhat similar approaches, have attempted to correlate the chemical structures of coal with those of other carbonaceous substances. Eklund, instead of using carbon and hydrogen percentages for purposes of correlation, transposed such data to a triangular atomic carbon-hydrogen-oxygen diagram to show structures of chemical compounds represented by the substances under study. Van Krevelen's later use of atomic hydrogen/carbon and oxygen/carbon ratios in plotting data for the coal series has much to commend it, because it makes possible the evaluation of geochemical processes in coalification. By superimposing upon van Krevelen's coal diagram data available for other types of carbonaceous substances, it has been possible to establish certain relationships or lack of relationships among these various substances.

One important observation has been that substances showing no

microscopic plant structure and having atomic hydrogen/carbon ratios of 1.0 or higher are probably not related to coal, whereas those with ratios less than 1.0 may or may not be related to coal. It has also been observed that there is a broad distribution of points on van Krevelen's diagram when data are plotted for any specific class of substances such as the asphaltites.[7] It is not known whether this distribution represents a problem in nomenclature, whether each asphaltite differs from the others genetically, or whether the various points for asphaltites represent stages of metamorphism. Until some of these questions can be answered by the accumulation of additional data and interpretative studies, it will not be possible to determine what physical and chemical processes are effective in the formation of many of these substances. Much discretion in choice of nomenclature must be exercised to prevent the establishment of unfounded and unproved theories with regard to the origin of a carbonaceous material.

Most naturally occurring carbonaceous substances are exceedingly complex and cannot be identified, characterized, or classified solely on the basis of visual observation. Certain simple tests can assist in the preliminary classification of these substances and can be of real value in maintaining unambiguous communication between chemists and geologists. For this purpose it is suggested that an unknown carbonaceous material be treated with carbon disulfide and that, if soluble, the material be considered "asphaltic" in nature. If it is not soluble, and if it exhibits woody structure under a hand lens or microscope, the material can be classed as coal or coalified wood. When no woody structure is evident, the nature of the material must be considered unknown pending more detailed chemical study, and it is recommended that no particular name be applied, but that it be termed merely "carbonaceous material" until such time as it can be more clearly characterized. It is hoped that use of innocuous terminology will eliminate nomenclature that tends to obscure the origin, nature, and interrelationships of various types of naturally occurring carbonaceous substances.

Organic geochemistry, as defined in part by the studies discussed in this paper, plays a role in the geochemical cycles of many elements. The part played by organic substances in such cycles will be defined only through the efforts of chemists, geologists, and biologists working as a team.

This investigation is in part the result of work undertaken by the Geological Survey on behalf of the Division of Raw Materials of the United States Atomic Energy Commission.

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EFFECT OF SORPTION ON METAL DISSOLUTION IN AQUEOUS ACID SOLUTION*

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There is little question that corrosion of metals in aqueous solution occurs partly, if not wholly, by electrochemical means. Nor is there much question that polar organic compounds, added to these solutions, retard the dissolution rate by virtue of adsorption. There is, however, considerable difference of opinion as to the site of adsorption, the nature of the attachment, and the function of the sorbed molecule in providing inhibition.

The hypothesis most widely accepted for inhibition in recent years is based on the effectiveness of compounds capable of forming onium ions. The cations are said to be attached to the metal at "local cathodes" by electrostatic attraction, and to inhibit metal dissolution by stifling the cathodic reaction.[1] Prediction of inhibitor efficiency is based largely on the area of the surface the molecule is capable of covering.

Another view[2] holds that the polar organic inhibitor influences the local cathodes by its effect on hydrogen activation overvoltage. This is a poisoning action which is quite properly considered to require firmer binding than that likely to be required by electrostatic forces in the high dielectric medium. In a fully aerated system, this mechanism loses plausibility because the cathode reaction becomes reduction of oxygen rather than of hydrogen ion.

A third suggestion[3] is that physical adsorption takes place generally over the metal surface, and that retardation then becomes wholly a matter of a barrier effect. Physical adsorption would accordingly work equally well as a diffusion barrier or as an ohmic resistance.

There are variations on these ideas, but those mentioned give the essence of the position. Each can explain some of the experimental observations, but none is broadly applicable. Moreover, each neglects at least one aspect of the adsorption step, and none considers the possible perturbation caused by the adsorbate particle on the ions in the lattice to which it is attached.

Requirements of An Inhibitor Theory

The literature on corrosion inhibition is extensive, but much of it is

*This paper, illustrated with lantern slides, was presented at a meeting of the Section on October 5, 1954.

contradictory. An up-to-date critical review is not available, nor is it possible to go into detail on this subject here. It can be stated, however, that a few striking points are evident, and that these points can be documented by reference to one or two fairly comprehensive articles. [4,5] The outstanding points are given below.

Many, if not most, of these inhibitors are specific in their action: that is, one compound effective in a certain medium with a given metal may be an accelerator of the dissolution rate for the same metal in another medium, or for another metal in the same medium. Indeed, the metal, the solution, the inhibitor and its concentration, and the temperature all play some part in the over-all process. This involvement suggests that nonspecific general adsorption or electrostatic attachment alone cannot account for inhibition. If it could, to a first approximation all inhibitors should be equally effective with all metals. Such variations which did exist would depend on differences in solubility or on molecular size, and these differences do not account adequately for the large variations observed.

There are numerous instances of the inhibitory effect persisting for appreciable periods after the inhibitor concentration has been deliberately reduced, even to zero. In such circumstances the inhibitor molecule unquestionably remains on the surface. This might be because of (a) a surface reaction causing complete conversion of the metal surface to an insoluble barrier, or (b) the formation of a chemical bond which did not seriously disturb the metal-metal bonds in and near the surface. The first possibility exists for some organic inhibitors, *e.g.*, fatty acids on iron, but is not likely with others, *e.g.*, amines on iron. The second possibility may be considered as chemisorption, and is the basis for the theory of inhibition given below.

Another experimental observation involves the change in irreversible potential of the metal in the acid solution on addition of inhibitors. The potential changes range from a few millivolts to a few hundred millivolts and in a large majority of the cases tend toward more noble values. It can be shown that the cathodic shift can come about because of polarization of the anode reaction or depolarization of the cathodic reaction. However, to account for a simultaneous cathodic shift and reduction in corrosion current (dissolution rate) it is necessary to conclude that the anodic effect must be greater than the cathodic effect. It is evident that this runs contrary to the effect expected on the basis of at least two of the earlier theories. One other possibility exists to account for the cathodic shift, namely that the adsorbed layer is an ohmic resistance which determines the measured potential of the metal. In other words, if the barrier layer were a sink for part of the potential drop developed at the anode, it might be possible to show that the cathodic shift should occur. This possibility has not yet been fully analyzed.

A More Comprehensive Hypothesis of Inhibitor Effects

It is evident that physical adsorption alone is insufficient to account for the effects noted and that adsorption at cathodes* alone does not fully take care of the problem.

Hence it is suggested that: (a) adsorption is general over the surface, *i.e.*, it is not controlled decisively by the areas of local electrochemical reaction; (b) some of the sorbate is held by chemical bonds and some by physical forces; and (c) all of the sorbate functions as a barrier but, in addition, the firmly held material reduces the inherent reactivity of the metal in the areas where it is attached. The important additions in this hypothesis are the removal of restrictions on the kind of sorption and the location of the sorbate, and the significant influence attributed to the chemisorbed particle. The latter addition might be thought of in terms of stabilization of the metal ions *in situ* or as a "surface complex."

This theory accounts for persistence, specificity, and cathodic shift. In fact, the existence of actual anodic areas is not required, since a reduction in tendency for the anodic reaction to occur necessarily requires the potential to be more cathodic (more noble). Incidentally, a problem which plagues all work in this field is the nature of a clean surface. It is possible that oxides exist on the metal, although in the strong acid solutions with hydrogen being evolved this is not likely. If the oxide were involved, however, arguments similar to those advanced for metals can be made for oxide-covered metals.[7]

Experimental Support for the Hypothesis

Two kinds of evidence can be cited in support of the contentions made: one demonstrates that firm adsorption does occur and that this portion of the sorbed material is more effective in reducing dissolution rate than is the physically adsorbed material; the other relates molecular structure to retardation effects directly.

Adsorption experiments with metals, generally as powders, have been described[8-10] which show that some portion of the adsorbate is held more firmly than is the remainder. This phenomenon is demonstrated by the difficulty of removing all the adsorbate by washing with fresh solvent. It has even been reported that results were the same in the presence or absence of a covering oxide layer.[8] The effect of adsorbing stearic acid from benzene solution onto steel powder is an interesting case in point. About 20 per cent of the uptake from a 15 mM solution could not be removed by continued and vigorous washing with fresh benzene. The total

* The concept that local anodes and cathodes are inherent to the metal probably needs revision. The separate potentials can just as well be considered to be induced at a given locality by the reaction taking place at that point. In this connection, a paper by Petrocelli[6] is of interest.

pickup was equivalent to about two full layers, assuming a cross section of 21 A^2 for the molecule, and 0.45 of a monolayer was held firmly.[10] Samples treated to provide metal with the total uptake or with only the 0.45 monolayer were placed in 4N HCl, and the rate of hydrogen evolution, in the first few minutes, were compared with that caused by an equal weight of untreated metal in the same time. The metal with the full adsorption layer on it reduced the rate by 62 per cent, and that with the firmly adsorbed material only reduced it 38 per cent. Hence, about one quarter of the total uptake accounted for three fifths of the total reduction in reaction rate.[11] This difference shows the extra effectiveness of chemisorbed material. Further, similar experiments with other members of the 1-n-aliphatic acid series showed that the amount of firm adsorption and the effect on dissolution rate was essentially independent of chain length in the range between 10 and 18 carbon atoms. Total adsorption increased slightly but regularly with molecular weight, and corresponding changes in the inhibition effect were noted. Also, with other 1-n-alkane series, the amount of firm adsorption was a function of the polar group, while the total pickup was determined by the chain length. This effect begins to give some insight into the question of specificity.

The nature of the bond can be considered on the basis of the metal-inhibitor combination as a Lewis acid-base pair. Either component can act as the acid or the base, but most of the available work requires the metal to act as the electron acceptor. In this case, for a given metal, firmer adsorption and more effective inhibition should be obtained with compounds containing functional groups of high electron density and high electron availability. This effect is modified to a larger or smaller extent by inhibitor solubility, geometric factors, state of aggregation in solution, and kinetics of adsorption. For instance, high molecular weight compounds of low solubility may change the wetting characteristics of the surface to such an extent that differences ascribed to type of bonding may be obscured.

To show the differences, therefore, relatively simple compounds must be considered. As an example, o-toluidine is a better acid inhibitor for steel than is aniline, and so is benzyl amine. In each case the explanation is that the electrophilic phenyl group which tends to reduce the electron density on the nitrogen is offset to some degree by the methyl and the methylene group respectively. Similarly, the presence of an additional electrophilic group such as $-NO_2$ on aniline should produce an even less effective inhibitor. In the series $(C_2H_5)_2O$, $(C_2H_5)_2S$, $(C_2H_5)_2Se$, the theory predicts that inhibitor effectiveness should increase to the right because of increasing ease of electron transfer from the Group VI element. A direct comparison for all of these under the same conditions is not available, but the order definitely holds on

comparing results as closely related as possible. Examples are given in greater detail elsewhere.[5]

The theory is not capable of fully explaining all effects by any means. For instance, predictions concerning functional groups such as -CHO and >CO are based only on a vaguely defined "reactivity." Furthermore, the sulfonates which are quite effective inhibitors have not been accounted for adequately. In an attempt to account for differences observed with different metals, use is made of the electronic work functions as a rough index of their avidity for electrons. This has been found to be inadequate, and a further step has been introduced via charge transfer complex theory.[7] Development past the point suggested in the paragraph just above, however, is largely speculative, and is not likely unless results from a large body of carefully executed, systematic experiments become available.

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SECTION OF BIOLOGY

MARINE FISH EGGS AS EXPERIMENTAL MATERIAL*

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A vast majority of investigators in the field of experimental fish embryology have concentrated on a very few species of teleosts. From over 30,000 known species, they have selected the killifishes *(Fundulus)*, trout and salmon *(Salmo)*, and the goldfish *(Carassius)*. A few additional, fresh water forms have been used sporadically. In Doctor Jane M. Oppenheimer's review[1] the generalizations on the organization of the teleost blastoderm were based on investigations using only these few species, all fresh water or euryhaline types. Among studies on the strictly marine fishes, descriptive reports predominate. These are of the type which have originated from the United States Bureau of Fisheries laboratory at Beaufort, N.C., and the Stazione Zoologica at Naples, Italy. The latter has been publishing a series of monographs and short papers on the eggs and larvae of teleosts. Numerous other marine stations over the world have contributed to such descriptive studies. It is surprising that, considering the space available in all these marine laboratories, so little experimental work has been reported on marine species. Several factors may account for this. Many marine fishes produce extremely small, fragile, pelagic eggs. The adults are often difficult to maintain in small aquaria, and can rarely be brought into spawning condition even by the use of pituitary extracts. Marine fishes typically possess pelagic larval stages, and no reliable laboratory methods have yet been devised which will permit these larvae to grow and metamorphose.

The kind of teleostean egg usually considered as typical is that of *Fundulus* or *Salmo*. The yolk is fluid, translucent, and is many times the volume of the blastodisc. The proportion of yolk, however, may be greatly reduced in some forms. In many of the Gobiidae, in particular in *Gobionellus*,[2] the yolk is only one-half or one-third the total egg volume. Fish eggs are generally spherical, but, as described by Breder,[3] many species depart drastically from this shape. This departure is most evident in the eggs of gobiid fishes.

I should like to present to you a species of teleost with excellent possibilities as a subject in experimental embryological research. This

* This paper, illustrated with motion pictures, was the first of two papers presented at a meeting of the Section on October 11, 1954. The investigations on which this report is based were carried out at the Lerner Marine Laboratory, Bimini, Bahama Islands, B. W. I., and the Marineland Research Laboratory, Marineland, St. Augustine, Fla.

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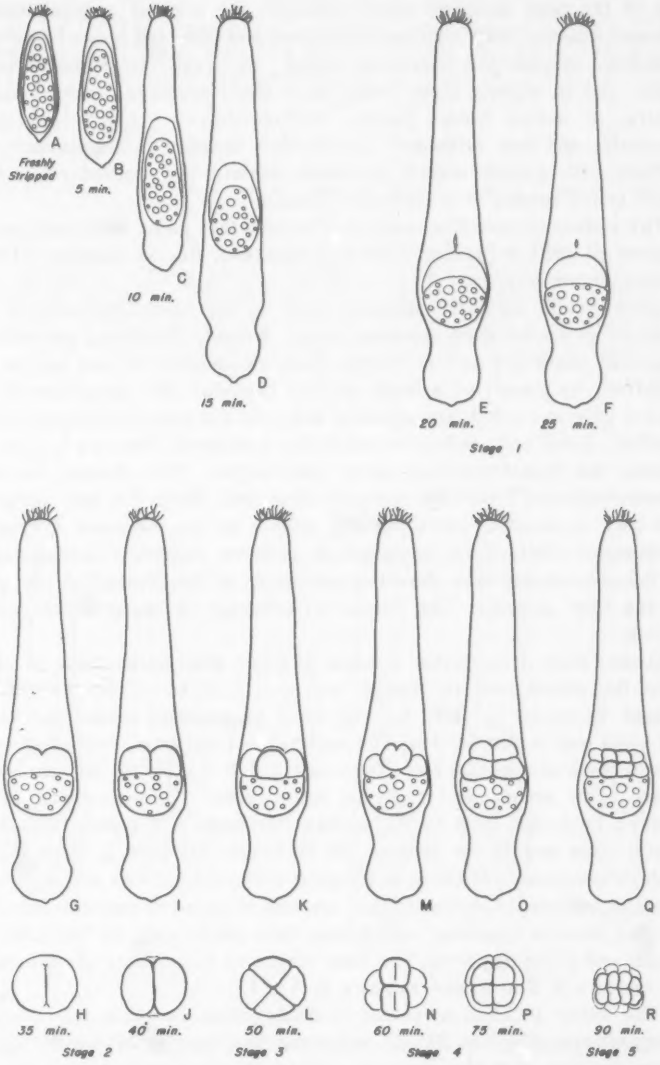
A
Freshly Stripped
B
5 min.
C
10 min.
D
15 min.
E
20 min.
F
25 min.
Stage 1
G
I
K
M
O
Q
H
35 min.
J
40 min.
L
50 min.
N
60 min.
P
75 min.
R
90 min.
Stage 2
Stage 3
Stage 4
Stage 5

FIGURE 1.

species is a gobiid fish, *Bathygobius soporator* (Cuvier & Valenciennes), one of the most abundant shore fishes in the tropical and subtropical Western Atlantic. It is common in shallows and tide pool areas from North Carolina, through the Caribbean region, to Brazil. It is secretive in habit, and is always to be found in or about crevices, empty mollusc shells, or similar hiding places. *Bathygobius* is a hardy species in captivity, and can withstand considerable changes in temperature and salinity. It spawns readily in small aquaria and possesses a long reproductive season of at least five months. [4]

The motion picture film used to illustrate this paper was made in the summer of 1953 at Marine Studios, Marineland, Fla. A summary of this motion picture follows.

The female deposits adherent eggs on the inner surfaces of the shelter, while the male releases sperm. Freshly deposited unfertilized eggs are about 0.8 mm. in length. Each is attached at one end to the substrate by means of a brush of thin threads. The cytoplasm of the animal pole is toward this attached end, and the yolk is oriented toward the free, distal end, where the micropyle is situated. FIGURE 1, A to D,* shows the transformations after fertilization. The chorion becomes "water-hardened" into an elongate structure, about 2.4 mm. long and 0.4 mm. in breadth, while the egg rounds up and becomes suspended within the shell. Time-lapse motion pictures illustrate the expansion of the chorion and also show the pulsations of the blastodisc just prior to the first cleavage. The pattern of cleavage is shown in FIGURE 1, E to R.

Gastrulation is completed at about 11 hours after fertilization, at which time the neural keel is visible (FIGURE 2, A to F). In the tail bud stages (FIGURE 2, G to L), the head is oriented toward the basal, attached end of the chorion. The earliest tail and trunk twitching movements begin at about 20 hours (FIGURE 2, J to L). By the 24 hour stage, these slow movements result in the reversal of the position of the embryo (FIGURE 2, M to P), so that the head now points toward the distal, free end of the chorion. At 30 hours (FIGURE 2, Q to R), the embryo continues twitching at irregular intervals but has now grown too large to reverse its position. This reversal in position becomes important at the time of hatching, which can take place only by rupturing the distal end of the egg shell. The later stages up to hatching are illustrated in FIGURE 2, S to U, and FIGURE 3, A to I.

The entire incubation period in *Bathygobius* is about four days, at temperatures of 27° to 29° C., and about five days at 24° to 26° C. The male remains with the eggs throughout this period and fans them at frequent intervals. As many as 15,000 to 18,000 eggs may be laid at a

* The figures are reprinted from the Journal of Morphology, 1950, 87: 472, 476, 480.

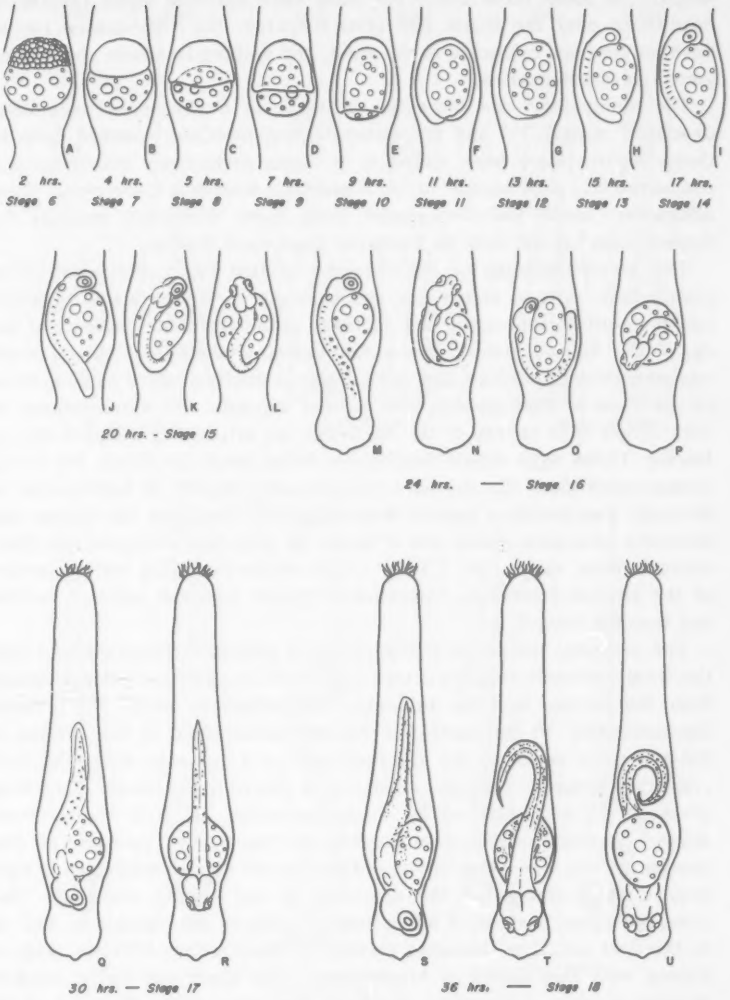

FIGURE 2.

single spawning, and, at hatching, most of the larvae emerge within a span of a few minutes. The hatching process is aided by strong fanning and brushing movements on the part of the male.

The larvae (FIGURE 3, J to K) are 2.2 to 2.3 mm. long at hatching. They are pelagic and mildly phototactic in habit. They increase in length

slightly in about three days, but none have survived under laboratory conditions past the fourth day after hatching. No *Bathygobius* larvae have as yet been collected in the field, and nothing is known about their growth or transformation.

The embryology and spawning behavior in *Bathygobius* have been described earlier,[4, 5] and the embryological problems touched upon in these reports have been added to in some preliminary investigations conducted this past summer at the Marineland Research Laboratory. Some additional ideas and techniques have been described recently by Oppenheimer[6] in her work on European species of *Gobius*.

The water-hardening of the chorions of fish eggs appears to be a phenomenon akin to activation, and consists of an imbibition of water into the perivitelline space and a change in the colloidal structure of the egg shell.[7] In most fishes, this water-hardening takes place upon contact with the external medium and does not necessarily require insemination. In the case of *Bathygobius*, the chorion expands and water-hardens in only 20 per cent or less of the eggs that are artificially stripped from a female. These eggs remain fertilizable for at least six hours, but in the nonexpanded group the chorions elongate only slightly if fertilization is delayed. Two problems present themselves: (1) how does the ovarian and follicular structure preset the chorions so that they elongate into their characteristic shape, and (2) how is the water-hardening and expansion of the chorion related to activational stimuli from the external medium and from the sperm?

The cleavage pattern in *Bathygobius*, in particular the transition from the 4-cell to 8-cell stage (FIGURE 1, K to P), presents a distinct variant from the pattern in other teleosts. The relatively small yolk volume (approximately 50 per cent) and the restrictive force of the chorion in the equatorial region of the egg contribute to a situation where the third cleavage, although vertical, results in a two-tiered blastula. This third cleavage is accomplished by a reorganization of cells at the 4-cell stage.[5] Further investigation emphasizes the role of pressure in this reorganization. The weight of an ordinary cover slip on *Bathygobius* eggs results in a change in the direction of the second cleavage. This cleavage plane, instead of being perpendicular to the equator as well as to the first cleavage, becomes parallel to the equator. A 4-cell stage is formed with two layers of blastomeres. The upper two cells, slightly smaller in size, continue to divide in the same plane. Removal of the chorion, on the other hand, results in vertical cleavages continued at least to the 32-cell stage. The cells spread out over the yolk in a sort of premature epibolic movement.

Manipulations involving the removal of the chorion are simplified by the elongate shell, which can be handled with instruments without

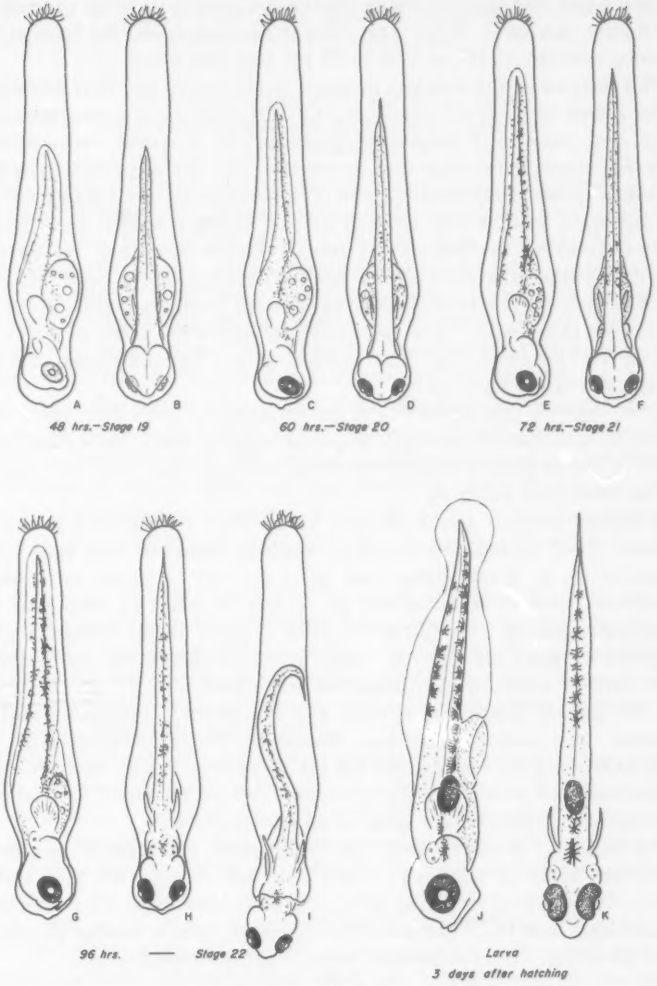

FIGURE 3.

danger to the embryo proper. The large perivitelline space could be used for injection of chemical and biological materials. In species of *Gobius*, Oppenheimer[6] found that the dechorionated embryos survive best in solutions of one part of sea water to three parts of Ringer's amphibian solution. Such specimens can be successfully used in dissection, explantation, marking, and grafting experiments.[6] In my own observations,

I have found that dechorionated *Bathygobius* embryos of up to stage 15 (20 hours) survive in 30 per cent filtered sea water, and the later stages develop normally in 50 per cent to 75 per cent sea water.

The reversal of the embryos in stage 16 (24 hours) was first considered to be a type of geotactic response, since it took place most regularly in eggs that were in a suspended position.[5] More recent observations,[4] however, have shown that this is not the case for eggs that have been normally spawned and brooded, and it is thought that the fanning activity of the male affects the rotation of the embryos within their shells.

The hatching mechanism of teleost larvae has been reviewed by Hayes.[7] There is some evidence that, in *Bathygobius*, a rapid release of the hatching enzyme is stimulated by a strong brushing action on the part of the brooding male.[4] The mechanism by which the larva is stimulated is as yet unknown, but this problem offers an interesting field for investigation and speculation.

The eggs of this species can be obtained by collecting them in the field. In such cases, the eggs, attached within a shell, should be brought back to the laboratory together with the brooding male, who will continue to fan them until hatching.

Females become gravid every 7 to 16 days throughout the breeding season (May through September, in northern Florida). The eggs can be stripped on to glass slides and fertilized with a sperm suspension.[5] Frequent changes of water and an occasional brushing help keep mold from accumulating. This technique is particularly useful if small, separate batches of eggs are desired. Eggs in such batches can be transferred into various solutions, still attached to the slides.

The largest quantities of eggs and the greatest survival results, of course, from normal spawnings. Males are strongly territorial in habit and shelters must be provided for the spawning. These shelters can be constructed of almost any rigid, smooth-surfaced material. The details of the spawning behavior are given in an earlier report.[4]

In summary, it can be said that *Bathygobius soporator* is an abundant species, hardy in captivity. Large numbers of eggs are produced and easily obtained by stripping or from normal spawnings. The structure of these eggs and their pattern of development offer a number of problems and advantages in experimental embryological investigations.

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CULTIVATION OF ANIMAL VIRUSES IN EMBRYONIC TELEOST CELLS*

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The intensive activity in the past two to three years in the field of virus cultivation has emphasized the need for developing new substrates for supporting the growth of viral agents. This emphasis has been particularly true in the investigation of one of the most important biological reactions, virus-cell relationships, where limitations of current methods for propagating animal pathogens have made the bacteriophage an attractive area for research. While the desirability of using bacteriophages as models for virus multiplication is readily admitted, it is also obvious that the application of data from bacterial-virus experiments to such human and animal agents as poliomyelitis, eastern equine encephalomyelitis, foot-and-mouth disease, is an indirect method and requires a transposition of theory which may not always be valid. Of the so-called "true" animal viruses, it can be said that only the influenza type of agent has been studied in regard to the problem of virus growth within the cell.[1]

The present communication is concerned with growth of an animal virus in a new host. Whether the method for propagating an animal virus in aquatic embryonic forms, as exposed in this first report, will provide a useful tool for studying the mechanics of animal virus growth, remains to be seen. Certainly, the need for research in this direction provided, at least in part, impetus for the project.

Following a series of unsuccessful experiments with echinoderm eggs, an attempt was made to observe *in vitro* development of embryos of a viviparous fish, a species of *Gambusia* found in the waters of southern Bimini, Bahama Islands, B.W.I. It was soon apparent that the *Gambusia* embryos were well suited for our purpose. The first observation revealed that embryos in late stages of development remained alive and active for at least two weeks in a sterile environment, at room temperature (23 to 25° C.) in an Erlenmeyer flask containing a simple tissue culture medium with added streptomycin and penicillin. It was further noted that the early stages of the fertilized eggs of the *Gambusia* developed apparently normally under similar experimental circumstances into active young fishes. Before virus was inoculated into a single preparation, numerous

* This paper, illustrated with lantern slides, was the second of two papers presented at a meeting of the Section on October 11, 1954. The studies reported in this paper were aided by contract NR 134-173 between the Office of Naval Research, Department of the United States Navy, and the University of Miami, South Miami, Fla. The authors wish to express their thanks to the Lerner Marine Laboratory, Bimini, Bahama Islands, B. W. I., for assistance in making this study possible, and to Doctor Charles M. Breeder, jr., for helpful comments regarding zoological aspects of this report.

embryos of *Gambusia* in various stages of development were studied in roller tubes, in test tubes, and in Erlenmeyer flasks, under conditions of rest or motion.

A known strain of eastern equine encephalomyelitis (EEE) virus was propagated at room temperature (23 to 25° C.) in serum ultrafiltrate–Simms' solution–minced-chick-embryo preparations.[2] The supernatant fluid of the fourth generation of this type of culture constituted original inoculum for the *Gambusia* embryo study.

Preliminary examination of adult fish and their embryos was carried out in a local species, *Gambusia holbrookii*, obtained through the courtesy of Doctor Luis Rene Rivas, of the Departments of Zoology and Marine Biology, University of Miami, who provided the first specimens. However, all data for the virus growth experiments were obtained from embryonic forms of a species of *Gambusia* found in the waters around Bimini. It is impossible at this time to give a specific name to this *Gambusia* because of the present existence of an involved taxonomic situation, which need not concern us here. The fact remains that the material under discussion was obtained from the Lerner Marine Laboratory of the Department of Fishes and Aquatic Biology of the American Museum of Natural History.

A simple technique for obtaining sterile *Gambusia* embryos has been evolved and will be discussed in detail elsewhere.[3] Briefly, the anatomical approach for removal of embryos is through an opening made in the posterosuperior peritoneal membrane surfaces exposed by a tangential cut along a line starting between the anal opening and the anal fin and extending across the fish at a 45-degree angle. After the embryos are carefully removed from the gravid fish, they are washed in five parts of Hanks'[4] solution, minus the sodium bicarbonate, plus one part ox serum ultrafiltrate.[5] This procedure is carried out in a syracuse crystal placed in a petri dish, and the embryos can be examined leisurely, under sterile conditions, at low magnifications (15 to 30 times). Then the embryos can be selected as substrates for virus growth, injured and inadequate embryos being discarded.

A classification of embryos, based on relatively gross findings into five stages, has been made because no histologic studies have been done and all manipulations have been made under low magnifications. It therefore seems to be a matter of practicality to provide as liberal and as simple a classification as is possible to designate clearly those embryos which, in our hands–under the present experimental conditions–have proved to be good substrates for virus growth.

Stage No. 1 ranges from the earliest type of fertilized ovum found to that point in the development where the primitive streak (FIGURE 1) and the optic buds are noted under the microscope. At this stage, an individual embryo and its yolk measures approximately 2 mm. in diameter. When the optic vesicles are visible to the naked eye, stage No. 2 begins

(FIGURE 2). This stage lasts until the epineural melanophores appear. Stage No. 3 is characterized by an increase in epineural melanophores and the development of the caudal fin. This stage continues until the head protrudes out of the extraembryonic membranes. Conspicuous in the next stage, No. 4, is the tendency of the embryo to stretch out and begin swimming movements. At this time the distended yolk sac begins to be reduced and, when it has been absorbed almost entirely and we are dealing with a fish at its normal time of birth, the final stage, No. 5, is reached.

An attempt was made to compare the classification of embryos as described with other descriptions of embryonic development. No division of *Gambusia* embryonic development into stages was found in the literature, and the only possible comparison could be made with those described by Tavolga,[6] where fixed specimens of the related platyfishes were studied by sacrificing females in various stages of pregnancy. It was immediately apparent that the *Gambusia* embryo classification as described here includes multiple units of Tavolga's 26 stages, covering a period of 21.9 days. For example, stage No. 1 may be compared to Tavolga's first eight stages. A more accurate comparison cannot be made at the present time because Tavolga's descriptions refer to *in vivo* sequence of events, while the embryos classified for present purposes are part of an *in vitro* continuity. Furthermore, the data revealed that the five stages of development vary in relation to time postfertilization, depending on various factors of the *in vitro* system.

Present data have been derived from experiments in which the routine medium consisted of five parts Hanks' salt solution and one part ox serum-ultrafiltrate with 100 units of penicillin and 100 gammas of streptomycin per ml.

Assuming that virus growth depended on the presence of surviving or developing tissue, observation of signs of life in the embryo were carefully followed, e.g., peripheral circulation, heart beat, and contractions of skeletal muscles (which developed into swimming activity). This aspect has been of considerable interest, not only as a possible concomitant of virus activity, but also as a physiological tool. The reaction of the embryo to environmental changes has been immediate, the most conspicuous signal occurring in the circulatory system. In apparently healthy cultures, the heart beat of the embryos has been approximately 120/min. Extremes of 80/min. and 160/min. have been noted.

Since the project was started, the embryo cultures have been handled as ordinary tissue-virus cultures are manipulated in this laboratory. For that reason, in addition to stationary preparations at room temperature, roller tubes were employed and found to be highly satisfactory. Good results were obtained at high roller speeds, varying between 150 to 200 rph.,[7] and much of the data were accumulated under such circumstances. While it has not been possible to observe the effect of different roller

speeds (since only one apparatus was available), *Gambusia* embryos completely at rest have not supported virus growth for an extended period of time.

Several hundred cultures have been studied in regard to embryonic development and virus propagation. Of these cultures, numerous preparations were involved when attempts were made to evaluate the effect of such factors as ratio of tissue to fluid, selection of the most suitable embryo for virus growth, type of container best suited for virus growth, comparison of stationary cultures, and cultures in motion, the effect of washing embryos before adding virus, the effect of pH range on embryo development and virus propagation, intermittent aeration of cultures, presence or absence of latent viruses, effect of injection of fish tissue into mice, and degree of development in the *in vitro* preparations.

In continuous culture, three lines of *Gambusia* embryo preparations have been maintained through eight subcultures. The common ancestor for the three lines, now under study, was the same for the first five culture passages. The subculture inoculum for this continuous line of EEE virus in *Gambusia* embryos has been 0.1 ml. of the supernatant fluid. In all instances, quantitative increase of virus has been demonstrated in the presence of stage No. 2 embryos in 3 or 5 ml. of routine medium, the tubes being maintained at room temperature at roller speeds of 150 to 200 rph. With the exception of the first, fourth, and one of the eighth subcultures where single mouse titrations for the first two, and sixteen animal tests for the last were carried out, the number of mouse LD_{50} tests for the remaining cultures averaged 4.7. Mouse potencies, in one instance as low as $10^{-3.7}$ and in another instance as high as $10^{-6.3}$, have been obtained. The titer of the majority of the supernatant fluids of the cultures has ranged between $10^{-4.7}$ and $10^{-5.1}$.

Increase of virus potency in continuous passage can be demonstrated either by evaluation of each culture generation or by estimation of dilution of original inoculum. The highest point of mouse infectivity for most cultures has been obtained to date between the fourth and seventh day of incubation.

The site of virus propagation has been associated with the cells of the *Gambusia* embryo as demonstrated by the following type of experiment, which has been done four times. When multiple animal tests with the supernatant fluid of the seventh culture generation revealed a *rise* in mouse potency to $10^{-4.7}$ on the seventh day of incubation, the culture medium was removed and the embryos were washed four times. Fresh medium was added, and the developing *Gambusia* embryos were returned to the roller apparatus. At this point the estimated dilution factor of the first culture fluid was 20,000,000. The embryos were apparently not damaged by the manipulation, and a second *rise* in mouse titer to $10^{-4.1}$ was demonstrated in the culture fluid on the third day after the multiple washings. FIGURE 3 represents an embryo from a similar experiment with

the sixth culture generation. At the beginning of the experiment, the clump of embryos consisted of 15 late stage No. 1's (see FIGURE 1). At the time the embryo was photographed and the second rise in mouse titer was determined, eight vigorously swimming stage No. 4's were present in the roller tube culture.

Before the thesis can be accepted that EEE virus has propagated in *Gambusia* embryo cultures, certain questions must be answered. That a nonbacterial agent was present in the culture fluids was evident when frequent inoculation of mouse-infectious fluids failed to produce any type of growth in routine bacterial cultures. When placed in a cell-free control, the infectious agent was subject to a straight line deterioration in a predictable fashion, the rate of deterioration being consistent with the reports of Finkelstein, Taylor, Beard, and their associates.[8] In addition, it was necessary to determine whether *Gambusia* cultures, not inoculated with EEE virus, produced an infection in mice following intracerebral injection (*i.e.*, cell-controls). On more than 30 occasions, cultures without EEE inoculum were injected intracerebrally into groups of mice, which were then observed for more than two weeks. At no time did such animals show signs of illness, and this circumstance suggested not only that the mouse colony was free of latent virus, but that the *Gambusia* embryo cultures did not naturally carry a mouse-infecting agent.

The specific nature of the mouse agent propagated in *Gambusia* embryo cultures was established by four neutralization tests. The source of the virus neutralized was first-passage mouse-brain emulsion from the primary *Gambusia* culture showing quantitative increase in potency as well as supernatant fluids of fourth, seventh, and eighth subcultures. Two known anti-EEE serums were used in these tests, and neutralization indices varying between 3.0 and 4.1 logs were obtained.* The neutralization results were consistent with the known anti-EEE activity of the serums and specific details of the tests will be published elsewhere.[3]

After almost a year of intensive effort in this field of investigation, it appears that only a beginning has been made in a new field, and that the present data should be considered a line of departure for further work. This statement is based on positive findings, and is not to be confused with the edict made by Harris[9] almost 10 years ago, when generalizations regarding the role of virus growth in lower vertebrates were made from essentially negative data derived from impractical experiments with vaccinia in reptilian eggs.

There is reason to expect higher and less variable titers of EEE virus as *in vitro* conditions are clarified. Furthermore, it is to be anticipated other viruses will grow in this type of preparation. Such a belief is based on two facts. First, preliminary unpublished data with two other viral agents suggest that *Gambusia* embryos will be adequate and

* The authors wish to thank Doctor Morris Schaeffer of the Communicable Disease Center, Montgomery, Ala., for sending a supply of anti-EEE serum sufficient to carry out multiple tests.

interesting substrates. The second reason for expecting other viruses to grow in the presence of *Gambusia* or similar embryos is the history of virus propagation. Reference to any of the methods of virus cultivation now in vogue reveals that when an environment has been provided for the growth of one virus, numerous other viral agents multiply in the same environment. Furthermore, the number of viruses multiplying *in vitro*, as well as their titers, increase as investigators become more proficient in the technique. The histories of rabies and poliomyelitis are good examples of the last statement.

On the other hand, the history of poliomyelitis also suggests that a note of caution is necessary in prophesying results with new agents on untested cells. In the case of poliomyelitis, good growth was obtained in the presence of human and simian testicular tissue. The virus did not multiply in testicular tissue of mice, guinea pigs, hamsters, rabbits, or bulls.[10]

Conclusions

(1) The virus of eastern equine encephalomyelitis has been propagated in a new host, *Gambusia* embryos obtained from field specimens.

(2) Complete and apparently fully normal development of *Gambusia* embryos has occurred in the *in vitro* environment.

(3) A simple method for obtaining sterile embryonic tissue has been evolved.

(4) Standard *in vitro* conditions have been maintenance of *Gambusia* embryonic tissue at room temperature (23 to 25° C.) in roller tubes containing 3 or 5 ml. of fluid, the tubes being rotated at 150 to 200 rph.

(5) The standard fluid has consisted of five parts Hanks' salt solution plus one part ox serum ultrafiltrate.

(6) Virus potencies in individual cultures have varied from $10^{-3.7}$ to $10^{-6.3}$ by mouse intracerebral tests.

(7) Multiple neutralization tests with virus from various culture generations have established the specific nature of the propagated agent.

(8) Intracerebral injection of mice with *Gambusia* embryonic tissue, not inoculated with EEE virus, did not produce disease.

(9) EEE virus growth has been established through eight culture generations, quantitative increase of virus being demonstrated in each generation.

(10) Propagation of EEE virus has been associated with *Gambusia* embryonic cells as demonstrated by second rises in mouse potencies following multiple changes of culture media.

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THREE STAGES OF EMBRYONIC DEVELOPMENT *IN VITRO*

FIGURE 1. Stage No. 1, *Gambusia* sp. Early embryonic development *in vitro*. The primitive streak of the segmentation cavity can be seen. Magnification ×40.

FIGURE 2. Stage No. 2, *Gambusia* sp. Embryo development *in vitro*: Optic vesicles are prominent. A vascular network has developed and the heart is apparent as a pulsating tube. Depth of pericardial cavity has increased. Magnification ×32.

FIGURE 3. Stage No. 4, *Gambusia* sp. Embryo developed *in vitro* to an actively swimming form. Embryonic development progressed in nine days from Stage No. 2. In the first six days, simultaneous with embryonic development, approximately three logs of EEE virus *propagation* was observed by mouse test. Culture fluid was replaced by fresh medium. On the sixth day, the embryos continued to develop and a second rise in mouse titer approximating the first rise was demonstrated.

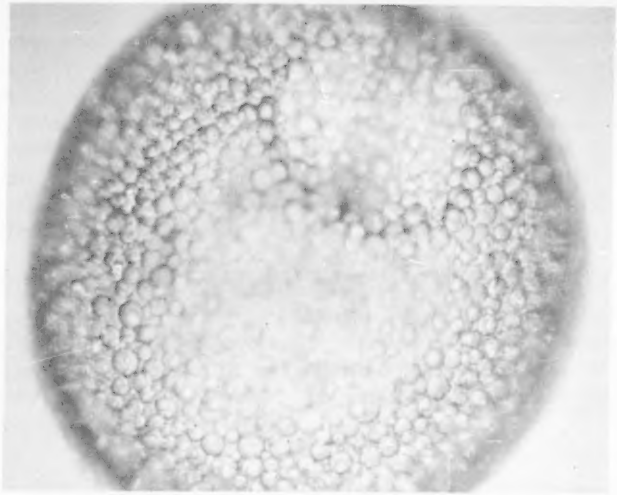

FIGURE 1.

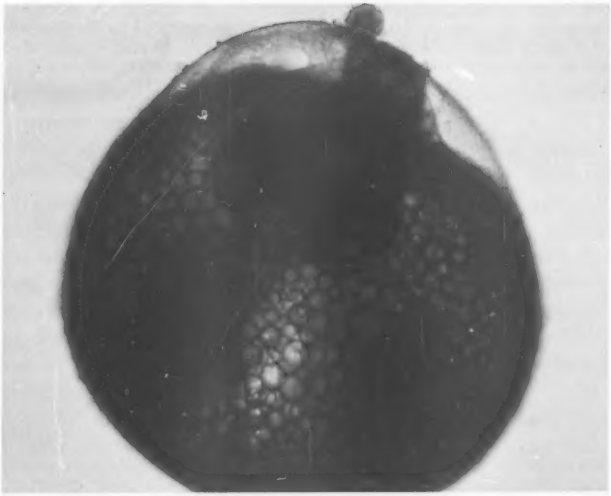

FIGURE 2.

FIGURE 3.

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SECTION OF MATHEMATICS AND ENGINEERING

CERTAIN OPTIMUM CRITERIA IN TELECOMMUNICATION SYSTEM PLANNING*

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It is usual, when projecting innovations which involve great expenditure, to inquire first into underlying factors, such as economic conditions throughout the country. It would seem that in the case of telecommunications this inquiry should be a reversed process. The development of our civilization is closely associated with the possibility of transmitting intelligence and, in this transmission, telecommunication plays an important role. By saving time and labor, telecommunication is an important factor in the promotion of civilization. It assists radically in the economic and cultural development of a country and in its business activities and social life, and it becomes a valuable asset in rural districts, where it saves the farmer the expense of long errands and assures other miscellaneous services.

From the viewpoint of social and national economy, telecommunication touches the everyday life of a nation more closely than does any other service. Telecommunication is a vast organization, worked by human agents of varying intellect and capacity, and the volume of its turnover is enormous. It is not only nationwide but world-wide and, in some ways, it is the most remarkable organization of all international activities.

Yet any knowledge of its technology, economy, and working is rare among ordinary average citizens. People casually dial or book their calls, or send and receive their telegrams. These calls and telegrams are handled by complex and delicate equipment, lines, cables, or radio, all subject to natural or malicious damage and to Nature's vagaries. The millions of words of telephone conversations and telegrams are converted into electric impulses of different combinations by man-controlled equipment. Often functioning under the most arduous conditions, telecommunication is playing its unobtrusive yet indispensable part in the life and economy of a country.

A telecommunication system may be compared to a chain composed of a number of links. The various possible systems are: (a) one-exchange system; (b) multi-exchange system; (c) zonal (area) system; (d) national system; and (e) international system.

The basic divisions of a telecommunication system are: (1) local exchange network; (2) junction plant; (3) long-distance plant, including

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(a) zonal (provincial) networks and (b) regional networks; and (4) international networks.

A complete and efficient system must incorporate all factors contributing to the intelligible transmission of speech between any two points, beginning from the sound conveyed to the microphone, its conversion into variable electromagnetic waves, and its final reconversion into a facsimile of the original sound waves at the point of destination.

A properly designed telecommunication system must not only prove satisfactory from the economic point of view, alike to those using it and and to those providing it, but must also satisfy the basic factors of strength and the quality of the signal reaching the listener.

It is not proposed to deal here with the technical and operating aspects of equipment except to say, in passing, that the quality of service provided by a telephone concern is an essential factor in its financial economy. In order to ensure satisfactory strength and quality, it is advantageous to plan such systems in accordance with certain standards. Outside the United States, these standards conform to the specifications of the *Comité Consultatif International pour la Téléphonie* (C.C.I.F.). In many aspects these standards are equal to those formulated by the Bell System in the United States.

The C.C.I.F. transmission requirements for the different types of systems are: national sending system, 20.5 db; international transit center, 0 to 3.5 db; and national receiving system, 16 db.

An engineer planning a system is usually confronted with the alternatives of providing: (a) a perfect but uneconomical system, or (b) an adequate system at a reasonable cost. The problem facing him is to analyze the various contributing factors and to determine an optimum system offering maximum efficiency at minimum initial investment and operating costs.

Cable Networks

Cable networks constitute 60 to 70 per cent of the total cost of a telephone system. Unlike the equipment in an exchange, which is now efficiently planned, the planning of cable networks is still, for the most part, done intuitively. This difference may perhaps be due to the fact that the cables, being underground, are out of sight and thus fail to receive the attention they deserve. The economic planning of cable networks, therefore, still presents wide scope for improvement.

I now propose to analyze two fundamental problems, namely: (1) optimum cable capacity (the most economic cable size); and (2) optimum exchange location (minimum cable length). The second problem also applies to optimum location of the junction points of secondary cables.

The planning of a cable network is generally based on the subscriber's end of the system. The distribution of the subscribers' network is based

on actual requirements and on statistical forecasts based on the social and economic nature of the area. The subscribers' distribution patterns determine the junction points of the subscribers' networks to secondary or primary cables, and the final routing of the main cables to the exchange.

The conduits and the cables, at the time of their installation, must have a capacity sufficient to handle not only immediate requirements for service but also a suitable reserve for the growth of the service for a number of years. From data based on extensive experience, it is now possible to state that the most economical planning period for main cables is 8 to 10 years and, for secondary branch cables and subscribers' cables, 15 to 20 years. The cost of cables per pair will become less as the number of pairs in a cable is increased, which explains the need for proper planning periods. This consideration would not apply to exchange equipment, which costs almost as much whether provided singly or in bulk, and therefore offers no economic advantage in reserve provisions for longer periods.

To determine the number of subscribers, the usual procedure is to estimate the density with the aid of statistical norms for the different economic and social classes of the city. The probable increase during the planning period is then determined with the aid of a suitable growth curve or analytical expression. A growth curve of the form

$$N(t) = N_o e^{\sigma t} \tag{1}$$

fits particularly well the growth of telephone traffic. $N(t)$ is the number of subscribers at time t, $N_o = N(t)$ for $t = 0$ (initial number of subscribers) and σ = average rate of growth.

On existing systems, the future growth is sometimes determined empirically by the extension of the growth curve of preceding years. Both these methods, however, if used indiscriminately, may lead to serious errors. Telephone expansion is closely interlinked with the economy of the country, its income, imports, exports, labor market, industry, *etc.* All these points must be borne in mind when estimating future possible extensions for the provision of suitable cable reserves for the given planning periods. Furthermore, in countries where saturation has almost been reached, as in the United States, the annual percentage growth is comparatively small. On the other hand, in new countries, or in localities having a new and expanding telephone system, the annual percentage growth will be comparatively large, falling off gradually as the number of subscribers reaches the saturation point.

If c is the number of possible subscribers and p the probability of a subscription the probability of x subscribers can be determined by the well known Bernoulli distribution approximated by Poisson's distribution

$$P_x = \frac{v^x e^{-v}}{x!} \tag{2}$$

where $v = cp$ is the expected number of subscribers (mean average) with the corresponding standard deviation $[cp(1-p)]^{1/2}$. An alternative approach is to consider the arrival of subscribers as a stochastic process, postulating that the subscriptions are independent.

Denoting by n the number of pairs in the cable, c_d the cost of the cable pair, p_d the expected revenue from the pair, the following two possibilities must be considered:

(1) $x \leqslant n$ when revenue will be $xp_d - c_d n$;

(2) $x > n$ when revenue will be $n(p_d - c_d)$.

It can be shown that the expected revenue from this cable will be

$$R_n = \sum_{x=0}^{n} \frac{v^x e^{-v}}{x!} (xp_d - nc_d) + \sum_{x=n+1}^{\infty} \frac{v^x e^{-v}}{x!} n(p_d - c_d) \tag{3}$$

and that this revenue will be a maximum when

$$R_{n+1} - R_n = (p_d - c_d) - \sum_{x=0}^{n} \frac{v^x e^{-v}}{x!} p_d \tag{4}$$

changes the sign from positive to negative.

If C_a is the total annual cost of the system and N the total number of subscribers' capacity of the system, then the annual cost per subscriber will be

$$p_N = C_a/N \tag{5}$$

The initial number of subscribers, N_o, however, is less than N, and it would not be equitable to charge all the cost to N_o subscribers. This number will grow during a number of years t_n when the full capacity N will be attained. If the life of the system $t_p > t_n$, the system will continue to operate at full capacity for the remaining period $t_p - t_n$.

If the growth of subscribers is not subject to chance fluctuations, and has a rate of increase proportional to the instantaneous subscribers' size, then the number of subscribers N, at any time t, will vary in accordance with the deterministic differential equation

$$dN(t)/dt = \sigma N(t)$$

and

$$N(t) = N_o e^{\sigma t}$$

This is the above mentioned formula (1). Putting $\sigma = \log_e(1+z)$, where z = rate of annual growth, expressed as a fraction of N_o

$$N(t) = N_o(1+z)^t \tag{1a}$$

The equitable charge can now be deduced from the expression

$$Np_N t_p = \int_o^{t_n} p_e N_o (1+z)^t \, dt + p_e N(t_p - t_n) \tag{6}$$

Since $z << 1$, $\log_e(1+z) \simeq z$
and with this approximation

$$p_e = p_N \frac{zt_p}{1 - \frac{1}{(1+z)^t n} + z(t_p - t_n)} \tag{7}$$

Optimum Location of Exchanges and Junction Points

If the cost of cable i is $C_i = c_i l_i$ where c_i is cost per unit length and l_i the length of cable i, then the total cost of the cable network will be

$$C = \sum_{i=1}^{k} c_i \sqrt{(x_i - X)^2 + y_i - Y)^2}$$

where x_i, y_i are the coordinates of the cable ends, X,Y the coordinates of the exchange or junction point location and c_i the above cost per unit length of cable i.

For the cost to be a minimum, it will be necessary for

$$\frac{\delta C}{\delta X} = \sum_{i=1}^{k} c_i \left(\frac{X - x_i}{\sqrt{(x_i - X)^2 + (y_i - Y)^2}} \right) = 0$$

and

$$\frac{\delta C}{\delta Y} = \sum_{i=1}^{k} c_i \left(\frac{Y - y_i}{\sqrt{(x_i - X)^2 + (y_i - Y)^2}} \right) = 0$$

The above expressions in their present form do not lend themselves to an explicit solution for X and Y in practical applications. However, by putting first that

$$X_o = \sum_i^k x_i / n_c = \bar{x}_i$$

and

$$Y_o = \sum_i^k y_i / n_c = \bar{y}_i$$

where $X_1 = X_o + \Delta X_o$

and $Y_1 = Y_o + \Delta Y_o$

and since $\Delta X_o^2 << X_o^2$

$\Delta y_o^2 << y_o^2$

one may write, as a first approximation,

$$X_1 = \frac{\sum_{i=1}^k c_i \frac{x_i}{\sqrt{(x_i - X_o)^2 + (y_i - Y_o)^2}}}{\sum_{i=1}^k c_i \frac{1}{\sqrt{(x_i - X_o)^2 + (y_i - Y_o)^2}}}$$

and

$$Y_1 = \frac{\sum_{i=1}^k c_i \frac{y_i}{\sqrt{(x_i - X_o)^2 + (y_i - Y_o)^2}}}{\sum_{i=1}^k c_i \frac{1}{\sqrt{(x_i - X_o)^2 + (y_i - Y_o)^2}}}$$

Since it can be proved that this iteration method is converging, greater exactitude is obtained by repeating this process, substituting X_1, Y_1 for X_o, Y_o and so on leading to the general expression

$$X_{u+1} = \frac{\sum_{i=1}^{k} w(u)x_i}{\sum_{i=1}^{k} w(u)} \tag{8}$$

and

$$Y_{u+1} = \frac{\sum_{i=1}^{k} w(u)y_i}{\sum_{i=1}^{k} w(u)} \tag{9}$$

where the weighting factor

$$w(u) = \frac{c_i}{\sqrt{(x_i - X_u)^2 + (y_i - y_u)^2}} \tag{10}$$

The full paper read before the Section of Mathematics and Engineering also included an analysis of the system decentralization problem, deriving expressions for an economic justification of satellite exchanges; a criterion for an economic distribution of subscribers in a multi-exchange area; comparative costs of systems; reliability of equipment; and topological properties of telecommunication networks.

SECTION OF PSYCHOLOGY

FLEXIBLE RETIREMENT PLANS AND MENTAL EFFICIENCY*

By George K. Bennett

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In recent years increasing attention has been directed to the older worker and the problems attendant upon his retirement. The social and emotional adjustment of the older person to retirement has become a topic of importance not only in the fields of psychology and sociology but also in business and industry. Efforts have been made to gauge the attitudes of the retiring employee toward social status and financial stability as well as his acceptance of enforced idleness or re-employment at an inferior level.

The National Social Welfare Assembly has organized a National Committee on Aging with about 200 members drawn from all parts of the United States. The majority decision at the first meeting of this committee was that compulsory retirement at a fixed chronological age was both socially undesirable and economically unsound. Consequently, a grant was made to provide the means for further investigation and the development of criteria for retirement at other than chronological age. Underlying this approach is the premise that many persons reaching the age of 65 are still employable, and would prefer continuance of their present jobs and earnings to retirement at a diminished level of compensation.

In a research study related to this topic, Doctors Tuckman and Lorge of Columbia University have conducted many psychological surveys of public attitudes concerning older people. These surveys reveal the existence of popular stereotypes of the aged and a fairly general agreement that retirement from usual employment should take place in the middle sixties.

In addition, an extensive study of the special problems of older persons has been undertaken by the Institute of Industrial Relations of the University of California. This study, sponsored by the Rockefeller Foundation, is divided into four categories: social, psychological, political, and economic. In his report "The Labor Force Status of Persons Aged Sixty-five and Over," Robert Dorfman states that only 41 per cent of the males over 65 are currently employed, and that 80 per cent of those not in the labor force have been separated from employment by reason of health or because they have reached the conventional retirement age. However, he also finds that only five per cent of those males over 65 are unemployed and consider themselves well enough to work and are interested in full-time or part-time jobs. Dorfman concludes that programs

* This paper was presented at a meeting of the Section on October 18, 1954.

of deferred retirement or re-employment will not provide a solution to the complex of problems resulting from the loss of employment status.

To what decision can a business organization come with regard to its older workers when confronted with these—and there are many more—schools of thought on retirement? If the employee is physically unable to work beyond the age of 65, the solution is apparent. However, if he is of comparatively sound physical health and the question is one of intellectual grasp, a satisfactory solution is not as readily apparent.

Thus far, the information available regarding the maintenance or deterioration of intellectual ability as measured by psychological tests has been meager. The British psychologist Vincent came to the conclusion that the decline of mean score on various intelligence tests with age could be regarded as practically constant and that the mean annual decline from age 21 to 60 is approximately 3/100 of a standard deviation. Vincent's conclusion may be illustrated as follows: A given type of test performance is found to attain its highest level at age 25. An individual who is at the median when 25 (surpassing half and surpassed by half of his fellows of the same age) at age 58 will have deteriorated in ability so that he will excel only 16 per cent of those who are now 25. Since other persons of his age have suffered similar declines, he will still excel 50 per cent of those who are now 58.

In contrast with this theory, data has been obtained from the testing of a sample of 1,700 men and women between the ages of 16 and 64. These data indicate that in terms of those tests which have been found most valuable in appraising mental ability, persons between 20 and 45 do better than those in their teens, while the older groups show only a slight loss, equaling in many instances the performance of persons 30 or 40 years younger.

In the course of standardizing a revised form of the widely used Wechsler Intelligence Scale, examiners employed by The Psychological Corporation tested persons in over 100 communities throughout the United States. The persons to be tested were carefully selected upon the basis of the United States census data so as to be representative of their age group in terms of occupation, education, and geographic location. Each person was given the eleven tests which, combined, make up the Wechsler Adult Intelligence Scale, the most widely used individual test of adult intelligence. The scale as a whole is divided into two parts, one of which is termed "verbal intelligence" and consists of six tests: vocabulary, similarities, comprehension, arithmetic, information, and digit span. On these tests, individually or as a whole, the persons in middle life tended to do better than those in their teens. Little diminution was found for persons between 45 and 64. The remaining five tests comprise the performance part of the scale and are named: block design, object assembly, picture arrangement, digit symbol, and picture completion. On these tests persons between 16 and 34 tend to do about

equally well, but persons between 35 and 64 show a perceptible loss in score, the loss increasing with advancing age. Even here, however, the peak of performance is not found in the early twenties, and the loss for older persons is considerably less than earlier research seemed to indicate. The data obtained from the two sexes reveal exactly similar findings for both men and women, and the data from one age group to the next fall neatly in line.

These findings should provide reassurance to older people, since they indicate that the older person is not intellectually handicapped, as compared with those freshly out of high school, and may reasonably consider changing his job, if he can find employment, or entering a course of study, or taking up a hobby if such a course should appeal to him. Employers may also feel more confident in retaining the old employee or considering a new employee whose age would previously have been regarded as a serious deterrent.

The study, in the course of which these data were collected, was jointly sponsored by Doctor David Wechsler, Chief Psychologist of Bellevue Hospital, and The Psychological Corporation, publishers of the test. Because of the great popularity and social importance of the Wechsler Adult Intelligence Scale, unusual care was taken in the preparation of the sample from which these data were drawn and in the administration and scoring of the test. It is felt that this study gives a more accurate description of the abilities of American men and women than any previous investigation.

It should be pointed out, however, that the factors determining retirement age are likely to be economic rather than psychological. In a period of national crisis, when there is a crying need for labor, job opportunities exist for all kinds of persons who normally find it difficult to get or hold positions. When employment falls, greater selectivity is exercised and the older person finds it difficult to gain employment or to hold his job beyond the standard retirement age. The solution seems not to be the retention of an older employee at the expense of failing to hire a younger one, but rather in the creation of new areas of useful activity for those who have reached the end of the normal working span.

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DIVISION OF MYCOLOGY

PROBLEMS AND SPECULATIONS ON THE DECOMPOSITION OF CELLULOSE BY FUNGI*

By R. G. H. Siu

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It is surprising that there are not more botanists and mycologists working today in the fascinating field of the decomposition of cellulose by fungi. The problem itself has a range of implications. It is a vital step in the maintenance of the important carbon cycle in nature. It contributes greatly in the formation of humus and the decomposition of plant trash in the enrichment of soil fertility. It is a key reaction in the invasion of plant tissues by pathogenic organisms. It is involved in the delicate symbiotic relationships between ruminant and insect hosts and the cellulose-digesting bacteria and protozoa in the gut. It plays a role in the breakdown of organic residues to form coals and oils. It is responsible for the hundreds of millions of dollars of annual damage to wood, textile, paper and other cellulosic products. And if one wishes to speculate, may not the mechanism of cellulose breakdown by fungi provide a partial clue at least to the reverse process of the synthesis of cellulose by plants?

Let us review the present state of knowledge on this problem, pointing out the very interesting unsolved questions and speculations. Perhaps such a presentation will stimulate and attract more research attention, which the field justly deserves.

In order to limit the coverage to a reasonable length, let us concentrate on the action of fungi on a pure form of cellulose, namely cotton fibers. We shall disregard the impure mixtures, such as wood, plant trash, rice hulls, dry leaves, hemp, and the like.

Fungi Attacking Cellulose

Cellulose-destroying microorganisms are found among fungi, bacteria and Actinomycetes, as well as among protozoa. There are the many species among the wood-rotting Basidiomycetes, which are well known to you. There are the many species among the Fungi Imperfecti, which have been frequently isolated from cotton textiles, paper, photographic supplies, rope, and other cellulosic substrates. For some time considerable disagreement existed, and still does exist, over the cellulolytic activity of a given isolate of fungi. This dissension is traceable to several

* This paper was presented at a meeting of the Division on October 22, 1954.

factors. First, there is the natural variation within a given taxonomic group. Within certain genera, such as *Chaetomium*, all species are capable of attacking cellulose. Within other genera, such as *Aspergillus*, only some species are cellulolytic; but the characteristic is generally constant for all strains within the given species. Within still other groups, such as *Penicillium citrinum*, some strains are cellulolytic and other strains are not. Second, there are the differences in the nature of the substratum used in the test. *Aspergillus luchuensis*, for example, is capable of attacking unbleached cotton fabric but not bleached.[1] Third, there are the differences in the assay conditions used by various laboratories. A temperature of 30°C., for example, may be too high for optimal activity by *Cladosporium herbarum*,[2] but too low for *Aspergillus fumigatus*.

As far as the geographical distribution of cellulolytic fungi is concerned, we should like to tell you about some interesting observations on the occurrence of cellulose-destroying fungi in the field. During the years 1944-1945, teams of mycologists visited various places in the tropical belt and collected samples of deteriorated cotton fabrics, and isolated fungi and bacteria from exposed cloth. The relative frequency with which cellulolytic fungi were isolated and tabulated. The results from three tropical locations are given in TABLE 1.

Trichoderma viride was abundantly common to all three locations. *Memnoniella echinata* was less frequently isolated but was also found in all three sites. Others were found frequently in two areas but not in the third, such as *Chaetomium globosum* and *Aspergillus terreus*. Still others were frequent only in one location and not so much in the others, such as *Penicillium luteum* in Florida.

Of course, the frequency of isolation in the laboratory does not mean that the frequency of occurrence of the fungi in the field is necessarily the same. We can dwell on this subject for many hours without coming to an agreement on the best workable approach on determining the frequency of natural occurrence of fungi in the field. Much work is needed to clear up this important methodology for ecological studies. In the absence of more rigorous isolation technique, we shall have to use these data as a rough index of natural frequencies.[4] Accordingly, it is interesting to conjecture why the organisms are distributed in this particular fashion. In particular, why is it that *Myrothecium verrucaria*, the most vigorous of cellulolytic fungi in the laboratory, requiring no particular nutritional supplements or temperature conditions and producing an antibiotic, is so rarely isolated from or observed on cotton fabrics exposed in the field? From laboratory observations, we should expect it to gain ascendancy and become widespread.

Platings from exposed fabrics showed *Trichoderma viride* to be the most abundant of the cellulolytic fungi isolated from fabrics. In Panama, for example, this fungus comprised over 11 per cent of the total fungal isolates. Yet the team of mycologists in the expeditions to the tropics

TABLE 1

DISTRIBUTION OF CELLULOLYTIC FUNGI ISOLATED FROM COTTON FABRICS AT THREE TROPICAL SITES[3]

Rank	Southwest Pacific		Panama		Florida	
	Name	% of total*	Name	% of total*	Name	% of total*
1	*Memnoniella echinata*	4.4	*Trichoderma viride*	11.1	*Penicillium luteum ser.*	5.4
2	*Chaetomium globosum*	4.0	*Fusarium solani*	3.0	*Chaetomium globosum*	3.5
3	*Trichoderma viride*	3.7	*Fusarium moniliforme*	3.0	*Trichoderma viride*	3.4
4	*Aspergillus terreus*	2.0	*Pestalotia virgatuia*	1.8	*Fusarium solani*	1.6
5	*Chaetomium funicolum*	1.8	*Fusarium javanicum*	1.6	*Aspergillus terreus*	1.4
6	*Cladosporium herbarum*	1.5	*Gliocladium roseum*	1.6	*Fusarium moniliforme*	0.7
7	*Aspergillus fumigatus*	1.4	*Fusarium semitectum*	1.0	*Gliocladium roseum*	0.4
8	*Thielavia sepedonium*	1.3	*Curvularia lunata*	0.7	*Curvularia lunata*	0.4
9	*Phoma terrestris*	1.1	*Penicillium luteum ser.*	0.5	*Memnoniella echinata*	0.3
10	—		*Memnoniella echinata*	0.3	—	

* Totals include all fungi, cellulolytic and noncellulolytic

has never recorded *Trichoderma viride* actually growing on fabrics, exposed in the field. In the laboratory, this fungus is vigorously cellulolytic. These ecological questions remain unanswered.

Nutrition of Cellulolytic Fungi

The nutritional response of cellulolytic fungi resembles that of other organisms. There are the same general requirements for inorganic salts, temperature, and conditions, which vary for individual species. There is the preferential utilization of simple sugars in a sugar-cellulose mixture by cellulolytic fungi, for example, which parallels the utilization of sugars in sugar-protein mixtures by bacteria. We do not believe, however, that we should devote our limited space to a review of such parallelisms. Instead, let us cover some of the extraordinary behavior patterns of certain species.

Gliomastix convoluta has an interesting nitrogen requirement. Contrary to other species of cellulolytic fungi, this organism cannot digest cellulose in an otherwise inorganic medium. It seems to require nitrogen in an organic form, such as yeast extract, casein hydrolyzate, peptone, urea, glutamic acid, and asparagine.[5] Why it should do so is a fine problem in metabolic specificity.

Another interesting case of nutritional specificity involves the magnesium and sulfur requirements of *Humicola grisea*, *Aspergillus fumigatus*, and *Actinomyces* sp.[6] The first organism decomposes cellulose only slowly in the absence of either magnesium or sulfate. Neither sulfate nor magnesium ion is substitutable for magnesium sulfate in equimolar concentrations. With the second fungus, the sulfate ion as sodium sulfate gives about as fast a rate of cellulose breakdown as magnesium sulfate. In the third case, the magnesium ion as magnesium chloride seems to be all important. No sulfate is required.

Mechanism of Attack on Cotton Fiber

There are many questions still unanswered in the penetration and subsequent digestion of the cotton fiber by fungi. Consensus exists on the initial generalized dissolution of the noncellulosic cuticle surrounding the cotton fiber.[7] Thereafter, there seems to be learned dust and controversy. Some workers[8,9] feel that the fungal mycelium gradually erodes the cellulosic layers from the outside surface inwards. Other authors[10] have presented photomicrographs suggesting a penetration of the cellulosic layers by the fungal hyphae directly into the lumen. This penetration is then followed by a digestion of the fiber from the lumen outwards. The photomicrograph raises a host of very fascinating research problems which are not being pursued at the present time. Is the initial point of penetration at the cracks in the surface or through proposed

pores in the cellulosic wall? Why is the hole perpendicular to the fiber axis? What role does the hyphal tip play in this pattern? Why is the attack apparently such a localized affair with digestion taking place at the point of immediate contact?

Mechanism of Breakdown of the Cellulose Molecule

There seems to be agreement on the greater susceptibility of amorphous cellulose to fungal decomposition and action by cellulolytic enzymes.[11,12] The work so far also indicates that there is a high degree of specificity between the cellulose structure and digestability by fungi. If an anhydroglucose unit is substituted chemically, it remains inert to fungal attack. If all of the units are substituted the cellulose derivative is resistant. It does not seem to matter whether the substituent is methyl, ethyl, acetyl, cyanoethyl, carboxymethyl, iodotosyl, tosyl, or carboxyl.[13] In this respect, it is interesting to note that methylcellulose is not digested by animals[14] and is used for aiding bowel movements as a bulk laxative.

At the present time there also seems to be general agreement on the feeling that the cellulolytic enzymes of fungi in general are adaptive in nature. Certain species such as *Aspergillus luchuensis*[15] and *Stachybotrys atra*[16] are exceptions. Bacteria, on the other hand, are constitutive.[17] Why *Aspergillus luchuensis* and *Stachybotrys atra* act more like bacteria in this respect is a mystery. Furthermore, it is puzzling how an insoluble substance such as a cellulose molecule can actually stimulate the production of cellulolytic enzymes? Do we have to invoke the theories of metabolic influences at a distance?

Although much confirmation is in order, indirect evidence[13] suggests a random splitting of the cellulose chain. There seems to be little argument on this score.

By far the greatest controversy of the day in this connection affects concepts concerning the biochemical steps in the breakdown of the cellulose molecule. There are four schools of thought on this matter.

The Delft group[18] follows a variation of the original proposal of a two-step system. Two decades ago, it was suggested[19] that cellulose is converted to cellobiose by the enzyme cellulase. The cellobiose is then split by the enzyme cellobiase into glucose, which is finally metabolized. The Delft group proposed a unienzymic nature for the thermoresistant cellulase, which splits cellulose into cellotriose, thereby producing cellobiose and glucose. At the same time these workers observed a thermosensitive cellobiase and a thermosensitive transglycosidase, producing a tricose from cellobiose. It is not certain at the moment whether the latter two are the same enzyme.

The Canadian group[20,21] feels that there is only a single enzyme involved in the breakdown of the cellulose molecule to glucose. It

obtained a preparation which was homogeneous electrophoretically as well as ultracentrifugally. Enrichment in the enzyme activity on cellulose and cellobiose were approximately the same, suggesting that the cellulase and the cellobiase of the Delft group are one and the same.

The Quartermaster group in this country[10,22] believes in a multienzymic sequence. First, there is a C_1 step, which attacks the cellulose molecule in the native matrix of the cotton fiber. This step is followed by C_x, which represents one or more enzymes. The C_x complex solubilizes the polysaccharide into glucose or cellobiose depending upon the microorganism.

Finally, there is the Australian group,[23] whose laboratory showed at least eight components capable of breaking β–glucosidic linkages in the metabolic filtrate of *Aspergillus oryzae*. This organism is unable to attack native cellulose. Therefore, the C_1 step postulated by the Quartermaster group is not involved. However, the results do suggest a multiple enzyme complex for the C_x system. The suggestion is advanced that there may be a family of β–glucosidases having the ability to break down polysaccharides within a particular range of chain lengths.

These few comments are sufficient to illustrate the welcoming need for more workers in the field. Disagreements need ameliorating; challenging problems await attention. Each of these groups is fairly well convinced of its respective conclusions. Time will tell which is closest to the truth. Despite the lack of consensus it may be worthwhile to speculate on what the experimental findings on the biochemical mechanism of cellulose breakdown mean.

Assuming there is such an initial enzymic step as C_1 what are the ramifications? There are no precise measurements of this factor as yet. Suggestions[24] have been made that it may be related to a swelling factor secreted by cellulolytic fungi in the medium. When placed in 18 per cent sodium hydroxide solution the enzyme-treated cotton fiber swells much more than the untreated fiber. But at the moment the identity is purely a conjectural possibility.

To pursue the nature of the C_1 further is to walk into a dilemma of difficult alternatives.[25] One alternative declares that C_1 behaves as the usual enzymes do and attacks covalent bonds. This action would require the presence of chemical bonds in native cellulose molecules other than the β–1,4-glucosidic linkages. This type of linkage has actually been suggested by certain workers,[26,27] but vigorously opposed by others. The C_1 would accordingly cleave these nonglucosidic linkages, liberating a straight chain polysaccharide. The C_x complex would then hydrolyze the β–glucosidic linkages of the linear polymer. Such a choice faces directly into the difficult controversy of the structure of the "native" cellulose molecule among cellulose chemists.

The other alternative leads into an even more intriguing alley. If one assumes that there are no covalent bonds other than the β–1,4-glucosidic

linkages in the polymer, then one must postulate that C_1 splits hydrogen bonds in the fiber. This effect would harmonize with the swelling factor idea for C_1, whereby the individual molecules are separated from each other in the crystalline matrix and exposed for action by C_x. But such an explanation would postulate a "hydrogen-bondase." If such an enzymic action can be confirmed, it would be a most elegant finding!

Concluding Extrapolations

Our brief discussion has pointed out some intriguing problems, which have been brought to the surface by the work on the decomposition of cellulose by fungi. There are many practical implications arising from these studies. These implications include new possibilities for the preservation of cellulosic material, clarification of fruit juices and digestion of low molecular weight impurities in cellulosic products. One may speculate as to the possibility of cellulose, partially digested by enzymes of the C_1 class, as a source of animal feed. In a more botanical line we may also speculate whether or not clues to the important synthesis of cellulose in plants can be derived from further studies on the transferase activity[28] of enzymes of the cellulase complex, whereby glucose is transferred as a unit from one molecule to another. These many problems[29] provide a most fertile field of research for mycologists and biochemists. It is hoped that they will attract a deserving amount of attention in the future.

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*SECTION OF OCEANOGRAPHY AND METEOROLOGY**

PRESENT STATUS OF WEATHER MODIFICATION**

By Howard T. Orville

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This discussion will consist of a brief review of the history of weather modification, followed by a brief summary of the developments and progress made in this field since 1947 when I became identified with Project Cirrus. The present status of weather modification as reported to the Advisory Committee on Weather Control will be summarized, and a few possible future developments will be mentioned.

It takes only a few minutes of research at the Library of Congress to find that rain making dates back many, many years. Rain making began to be recognized in the scientific world at the turn of the 19th century, when an approach was made, both in Europe and in the United States, to modify clouds with dry ice. Patents were issued for instruments and equipment to project dry ice into the clouds. Knowledge of cloud physics and of the upper atmosphere was far too scanty at that time to permit successful experimentation in cloud seeding.

The advent of aviation, World War I, and the eventual establishment of an upper air sounding system with kites and balloons led to further attempts at cloud seeding in 1930, when August W. Veraart[1] dispensed dry ice pellets and water ice in supercooled clouds from aircraft above the clouds. Veraart claimed that he had successfully produced rain artificially, basing his claim on a comparison of the precipitation in the seeded area with precipitation in the unseeded area. He was unable to convince the government of the Netherlands that his experiments were successful, however, and, lacking the necessary financial support, he was forced to discontinue his experiments. Following his efforts, Bergeron[2] and Findeisen[3] developed the ice-crystal theory and thus laid the foundation for the development of modern cloud-seeding methods and for experimental work in cloud physics.

The ice-crystal theory assumes that in the precipitation process, in mid-latitudes where heavy rain is occurring, there is a region of temperature, within the clouds, of between 0° C. and -40° C., and that further, within this region, coexisting ice crystals, supercooled water drops, and water vapor in a state of supersaturation will be found. Since the vapor pressure over an ice crystal is much lower than over a supercooled water drop, the ice crystals will grow at the expense of the water drops and finally become large enough to fall. As they fall they will continue to

* The Section of Anthropology held a meeting on October 25, 1954 at which a paper entitled "Some Aspects of Technical Assistance in Liberia" was read by Joseph Jablow. This paper will be published in a subsequent issue.

** This paper, illustrated with lantern slides, was presented at a meeting of the Section on October 26, 1954.

grow by collision with other drops on their downward descent through the cloud.

In present day cloud-seeding operations, it appears that there are not enough ice crystals in the critical temperature region to sustain the precipitation process Two methods are used to increase the freezing nuclei concentrations in great numbers. The one method is to introduce dry ice into the cloud; the other is to seed a cloud from below with foreign particles of some substance such as silver iodide, which performs the same function as the ice crystal.

Further interest in the field of rain making lagged until 1941, when Doctors Langmuir and Schaefer devised a method for producing an artificial fog and subsequently became involved in the basic study of precipitation static on aircraft and of aircraft icing.[4] This latter study led Doctor Schaefer to the discovery of a method of changing supercooled cloud particles into ice crystals. On Nov. 13, 1946, Doctor Schaefer, flying over western Massachusetts, dispensed dry ice from an airplane into a supercooled cloud and induced snowfall. This result gave positive experimental confirmation of earlier extensive studies made in a cold box.

Following Doctor Schaefer's historic flight in 1946, additional experiments were conducted in the early months of 1947. These experiments resulted in setting up a government-sponsored project known as Project Cirrus in which the United States Army Signal Corps and the Office of Naval Research, using planes and crews supplied by the Air Force, carried out extensive cloud-seeding operations under the technical guidance of Doctors Langmuir, Schaefer, Vonnegut, and others. During the next four years, extensive experimental flight studies (at times supplemented with silver iodide ground generators) were conducted over New England, New Mexico, Puerto Rico, and Florida.

It is not within the scope of this discussion to outline the details of the outstanding results of the research conducted by Project Cirrus. It is of interest, however, to note that the experimental cloud-modification methods developed by Project Cirrus are still being used today without substantial change. Dry ice of varying amounts is used to seed clouds by using airplanes, balloons, or projectiles. Silver iodide produced with a smoke generator is used for seeding the atmosphere, and this method has been found to be as effective as the use of dry ice under favorable atmospheric conditions. By use of the generators operating over long periods of time it is possible to seed large cloud systems. A third method of modifying clouds is to introduce large water drops into the active portions of cumulus clouds, thereby initiating rainfall artificially. This latter method is used in the tropics and subtropics where temperatures, even in the tops of clouds, are well above freezing.

Experimental evidence now at hand indicates that cloud-seeding methods are being used on potential thunderstorms to prevent the storm

from developing into destructive proportions and, especially, to prevent the damaging hail storms which often accompany severe thunderstorms. Cloud-seeding methods are also being used to increase precipitation from individual cumulus clouds and from cloud systems in areas experiencing subnormal rainfall. The use of cloud-seeding to increase the snowpack on mountain tops has become widespread throughout the western states. Increased snowfall is of greatest importance for the development of hydroelectric power and for irrigation.

Doctor Langmuir has suggested the seeding of a given portion of the atmosphere with a sufficient concentration of ice nuclei to start a chain reaction, in order to increase the probability of rain from any given synoptic situation. Such large scale effects are complex, however, and they are not sufficiently understood to receive general acceptance at this time.

In view of the divergent claims which arose from the experiments made by Project Cirrus, it was decided to establish another government-sponsored research project which became known as the Cloud Physics Project. Under the supervision of this project, the United States Weather Bureau, the United States Air Force, and the National Advisory Committee for Aeronautics made about 170 flight missions over Ohio, the Gulf States, and California. The experiments were carefully controlled, and, insofar as possible, complete observational facilities were provided to facilitate careful analysis of the results. The results[5] of these independent experiments on stratus and cumulus clouds were, in general, quite inconclusive in terms of the practical and economic results which were desired. The experiments made with dry ice frequently produced weather conditions which were valuable in that they added substantially to our totally inadequate knowledge of the precipitation processes.

Further interest in weather modification on the part of the government was demonstrated in the establishment, by the United States Department of Defense, of a new weather modification program following expiration of Project Cirrus in 1952. This new program, known as the Artificial Nucleation Program (ACN), is designed to obtain further experimental confirmation of cloud-seeding methods under selected weather situations. The United States Weather Bureau, Army, Navy, and Air Force are working on various phases of this program, and close coordination designed to prevent duplication is administered through the Office of Research and Development of the Department of Defense. The Weather Bureau conducted exhaustive aircraft seeding, with dry ice, of warm frontal conditions in the Seattle area. Field operations were concluded last April, and results are being analyzed at the present time.

It is of interest to note that, following the discoveries made by Doctor Schaefer, interest in cloud seeding spread rapidly to agricultural interests, ranchers, and industry, especially west of the Mississippi because of the critical water shortages existing in many of the western states.

Private meteorologists, a few pilots, and other individuals became interested in cloud seeding, and a commercial cloud-seeding business developed rapidly. It is estimated that in 1950-1951, commercial operations probably exceeded $3,000,000, but since then the business has stabilized to an estimated $1,000,000 annually. Cloud-seeding operations of one form or another have been or are now operating in almost every state of the Union. The worth of the results, however, is still questioned by many persons.

Foreign countries soon became interested in the new weather-modification methods and the possibility of increasing rainfall, and today there are cloud-seeding operations in many foreign countries. Australia has maintained an extensive government-sponsored program on weather modification since about 1947. Spain, Israel, Peru, Pakistan, Japan, and many other countries are experimenting with weather modification in one form or another.

Congressional attention was focused on federal regulation of weather modification as early as 1947, shortly after Project Cirrus was established. Bills on the subject were introduced in Congress as early as 1948, and extensive hearings were held on several bills in 1951.[6] It was not until 1953 that the bill setting up the Advisory Committee on Weather Control was passed by the 83rd Congress. This bill signed by President Eisenhower on Aug. 13, 1953, and becoming Public Law 256, requires that the committee "shall make a complete study and evaluation of public and private experiments in weather control for the purpose of determining the extent to which the United States should experiment with, engage in, or regulate activities designed to control weather conditions." The five members of the committee from private life were appointed by the president on Dec. 9, 1953, and their appointment was confirmed by the United States Senate on Jan. 25, 1954. At its first meeting, held on Dec. 18, 1953, the committee adopted four principles to guide it in its deliberations:

"First, the Committee will base its conclusions on facts obtained and interpreted, and not any preconceived notions. Experiments to date have suggested that weather control may eventually provide benefits to agriculture, industry, and government. Without such a hint of substantial benefits, the Congress would most likely not have created this Committee. However, the Committee will not proceed under the assumption that weather control, including rain making, does 'work' or does not 'work.' It will aim to examine all of the evidence with scholarly care and scientific impartiality.

"Second, the Committee recognizes the need for additional basic research dealing with processes related to rain, snow, and cloud phenomena. There is also a need to develop ways and means of providing methods for reliable evaluation of weather control activities. The Com-

mittee will encourage such research in industry, at our universities, and throughout government.

"Third, the Committee will welcome, and will solicit, the information possessed by and the opinions held by all individuals and groups having an interest in the field of weather control. It will carefully consider all facts and opinions pertinent to its study.

"Fourth, the Committee will not act in any way prejudicial to responsible individuals and concerns attempting to modify the weather."

During the ten months that the Committee has been operating it has:

(1) Held six meetings.

(2) Received more than 200 reports from private meteorologists or commercial companies and corporations.

(3) Received a large number of progress reports from government-sponsored projects.

(4) Made eight field trips to observe personally cloud seeding or weather modification operations. (Most field trips were made by small task forces of two or three members.)

(5) Been briefed on all phases of the ACN program.

(6) Consulted with or sought the advice of more than 70 outstanding scientists familiar with one phase or another of the field of weather modification.

(7) Established a program of evaluation projects to study all phases of weather modification.

(8) Accumulated over 50 technical evaluation papers.

(9) Established, on July 1, 1954, a staff headquarters with an executive secretary (Charles Gardner, Jr.), a chief scientific adviser (Captain F. A. Berry, United States Navy), and a small administrative and technical staff.

(10) Held two evaluation conferences, one at the Institute of Atmospheric Physics, University of Arizona, Tucson, Ariz., and the other at the Massachusetts Institute of Technology, Cambridge, Mass.

During this phase of the committee's operations, which is logically a fact- or information-gathering phase, the committee has been able to review what has actually happened in the entire field of weather modification. This preliminary review tentatively suggests three classes of data: (1) information about which there is wide acceptance and unanimity of opinion; (2) doubtful information needing further experimental confirmation; and (3) very doubtful information on which there is great lack of knowledge and understanding:

(1) *Acceptable Information:*

(a) Knowledge of the physics of clouds and the mechanism of precipitation is very incomplete and there is urgent need for much more research before we can hope to have a complete understanding of cloud modification.

(b) Supercooled stratified clouds can be dissipated by aircraft seeding with dry ice or silver iodide.

(c) Water seeding in warm cumulus clouds appears to be effective in inducing precipitation if clouds are more than 5000 feet thick.

(d) Dry ice seeding of cumulus clouds over 10,000 feet above 0° C. line and temperature of top of cloud -6° C. or lower will induce precipitation.

(2) *Doubtful Information:*

(a) The effectiveness of silver iodide seeding from ground generators in high summer temperatures and bright sunlight needs further experimental confirmation.

(b) The economic value of dry ice and water seeding except under special conditions.

(3) *Very Doubtful Information:*

(a) Large-scale effects of cloud seeding, a very controversial procedure requiring additional experimental confirmation.

(b) Over seeding, a procedure questioned by many persons.

(c) Hail and lightning suppression, a procedure requiring much more experimental confirmation.

In order of priority, though not exclusively so, the committee is considering the technical aspects of weather modification, the economic value of cloud seeding, and whether or not there is sufficient confirmation of the two previous phases, the legal aspects and possible federal regulations.

The committee will pay particular attention to any research leading to the discovery of new types of nucleating agents and new methods of dispersing these agents.

The present approach to the evaluation of weather modification has led to much criticism and misunderstanding. There is urgent need for the selection of more satisfactory criteria to determine the effectiveness of the several nucleating agents. Whether such criteria can be established or not remains to be seen.

If the Advisory Committee finds that weather modification projects can not produce important results, it will so report; and thus deter farmers and ranchers from spending their money unwisely. Such a report, if it has to be made, will save the public millions of dollars.

If the Advisory Committee finds that weather modification activities work only in certain circumstances, it will find out what those circumstances are, and thus encourage feasible projects and discourage those which are not feasible.

If the Advisory Committee finds that it can confirm reports received thus far from reputable and scientifically competent operators citing increases in precipitation of from 7 per cent to 50 per cent and more, then the dollar benefits to agriculture, industry, and government will be incalculable.

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CONFERENCES HELD

SECTION OF BIOLOGY

MOLECULAR EVENTS IN DIFFERENTATION RELATED TO SPECIFICITY OF CELL TYPE

Friday, October 8 and
Saturday, October 9, 1954

Conference Chairman: H. Clark Dalton
New York University, N. Y.

FRIDAY, OCTOBER 8

PATTERNS OF SYNTHESIS IN DIFFERENTIATION

Session Chairman: J. Philip Trinkaus, Yale University, New Haven, Conn.

9:00 A. M. -
Introductory Remarks - H. Clark Dalton, New York University, New York, N. Y.

"The Molecular Basis of the First Heart Beats" - James D. Ebert, Indiana University, Bloomington, Ind.

"Events Associated with the Differentiation of Nerve and Hepatic Cells" - Louis B. Flexner, University of Pennsylvania School of Medicine, Philadelphia, Pa.

"Substrate Utilization in Cell Differentiation" - Clement L. Markert, University of Michigan, Ann Arbor, Mich.

"The Role of Phenylalanine in the Differentiation of Neural Crest Cells" - Charles E. Wilde, University of Pennsylvania School of Dentistry, Philadelphia, Pa.

IMMUNO-BIOLOGICAL APPROACH TO PROBLEMS OF DIFFERENTIATION

Session Chairman: Edgar Zwilling, University of Connecticut, Storrs, Conn.

2:00 P. M. -
"The Role of Genes and Cytoplasmic Particles in Differentiation" - Ernest W. Caspari, Wesleyan University, Middletown, Conn.

"Development in the Presence of Antibodies" - George W. Nace, Duke University, Durham, N. C.

"The Reaggregation of Dissociated Sponge Cells"-Melvin Spiegel, California Institute of Technology, Pasadena, Calif.

"The Nucleus of the Cell and Cellular Differentiation"-A. M. Schechtman, University of California at Los Angeles, Los Angeles, Calif

SATURDAY, OCTOBER 9

PROBLEMS OF STRUCTURAL ORGANIZATION

Session Chairman: Elmer G. Butler, Princeton University, Princeton, N. J.

9:00 A. M. -
"Tissue Disaggregation in Relation to Determination and Stability of Cell Type"- Clifford Grobstein, National Institutes of Health, Bethesda, Md.

"Limb Regeneration and 'Overt Behavior' Differentiation in Urodeles as Studied by Means of Their Response to Chemical Agents" -Alexander G. Karczmar, Sterling-Winthrop Research Institute, Rensselaer, N. Y.

"Specific Inhibition in Growth and Differentiation" -S. Meryl Rose, University of Illinois, Champaign, Ill.

ROUND TABLE DISCUSSION

Moderator: Ernst W. Caspari, Wesleyan University, Middletown, Conn.

2:00 P. M. -
Round Table Discussion - Panel of Experts from Participants.

SECTION OF BIOLOGY

INSTRUMENTATION

Thursday, October 28 and
Friday, October 29, 1954

Conference Chairman: J. Greenspan
Process & Instruments, Brooklyn, N.Y.

THURSDAY, OCTOBER 28

THE SCIENCE OF INSTRUMENTATION

Session Chairman: W. A. Wildhack, National Bureau of Standards, Washington D. C.

9:30 A.M. –

"Instrument Research and Development at the National Bureau of Standards" – W. A. Wildhack, National Bureau of Standards, Washington, D. C.

"Medical Research Instrumentation" – R. L. Bowman, National Institutes of Health, Bethesda, Md.

"The Relationship Between The Process of Measurement and Instrumentation in Biology" – H. J. Morowitz, National Institutes of Health, Bethesda, Md.

"Measurement as a Human Activity" – J. D. Trimmer, University of Tennessee, Knoxville, Tenn.

THE TRANSMISSION OF INSTRUMENT REQUIREMENTS AND SPECIFICATIONS

Session Chairman: H. Grundfest, Columbia University, New York, N.Y.

2:00 P.M. –

"Instrumentation in the Atomic Age" – V. L. Parsegian, U. S. Atomic Energy Commission, New York, N. Y.

"Specifications as an Aid to Instrument Adaptation and Operation" – A. H. Petersen, Mellon Institute of Industrial Research, Pittsburgh, Pa.

"Instrument Requirements and Specifications in Bioelectric Recording" – H. Grundfest, College of Physicians and Surgeons, Columbia University, New York, N.Y.

"Instrumentation Problems Encountered in Clinical Research" – D. A. Holaday, Presbyterian Hospital, New York, N. Y.

"General and Specific Problems Involved in Diagnosis and Research by Means of Electronic Instruments in a Large General Hospital" – R. S. Schwab, Massachusetts General Hospital, Boston, Mass.

"Instrumentation Requirements in Sensory Aids" – W. E. Frank, The Franklin Institute, Philadelphia, Pa.

FRIDAY, OCTOBER 29

SOME EXAMPLES OF THE USE OF ANALOG INSTRUMENTS

Session Chairman: Ernst Weber, Microwave Research Institute, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

9:30 A.M. –

"Application of an Electronic Differential Analyzer for Biological Problems" – C. C. Yang, Johnson Foundation for Medical Physics, University of Pennsylvania, Philadelphia, Pa.

"Electric Analog Computers-Classification Design and Applications" – V. Paschkis, Columbia University, New York, N. Y.

"Transducers in Instrumentation" – D. B. Kret, Allen B. Dumont Laboratories, Inc., Clifton, N. J.

"Construction and Application of Membrane Analogs" – W. E. Rogers, University of Washington, Seattle, Wash.

SOME EXAMPLES OF THE USE OF ANALOG INSTRUMENTS (cont'd)

Session Chairman: J. Greenspan, Process & Instruments, Brooklyn, N.Y.

2:00 P.M. –

"The Application of the Electrolytic Tank to the Solution of Potential Field Problems" – C. Hachemeister, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

"Fluid Mappers as Visual Analogs for Potential Fields" (Demonstration) – A. D. Moore, University of Michigan, Ann Arbor, Mich.

"Concluding Remarks" – J. Greenspan, Process & Instruments, Brooklyn, N.Y.

NEW MEMBERS

Elected June 30, 1954

LIFE MEMBERSHIP

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SUSTAINING MEMBERSHIP

Altiok, Haydar, Cardiology, Chest Diseases. Jewish Sanitarium and Hospital for Chronic Diseases, Brooklyn, N. Y.

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Astor, Manuel Angel, M.D., General Surgery. Chief of Surgery, Hospital Dr. Maldonado Sierra, Hato Rey; Chief Surgeon, San Juan Diagnostic Clinic, Santurce, Puerto Rico.

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Bivona, Paul J., M.D., Biochemistry, Physiology. Associate Surgeon, Wyckoff Hospital, Brooklyn, N. Y.

Chase, Oscar J., Jr., D.D.S., Dentistry. New York, N. Y.

Gallant, Leonard J., M.D., Psychiatry. Assistant Professor, Psychiatry, Johns Hopkins University, Baltimore, Md.

Lorenz, Anton, Physiology, Body Mechanics. Buffalo, N. Y.

Snyder, Joseph E., M.D., Hospital Administration. Assistant Vice-President, Presbyterian Hospital, New York, N. Y.

Welch, E. Parl, Ph.D., Psychology. Private Practice, Beverly Hills, Calif.

ACTIVE MEMBERSHIP

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Acken, Henry S., Jr., M.D., Obstetrics, Gynecology. Senior Attending, Methodist Hospital, Brooklyn, N. Y.

Aitken, Frank J. T., M.D., Physiology, Pathology. Private Practice, Bridgeton, N. J.

Albano, Flora, D.D.S., Orthodontics. Private Practice, Malverne, N. Y.

Alberto, B. F., Ch.D., Chemistry. Research Fellow, University of Pavia, Pavia, Italy.

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Anderson, Jack Robert, M.D., Medicine. Otolaryngologist, Assistant Professor, Tulane Medical School, New Orleans, La.

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Young, Viola Mae, Ph.D., Bacteriology. Bacteriologist, Army Medical Graduate School, Walter Reed Medical Center, Washington, D. C.
Zobian, James G., B.S., Science Teaching. Science Teacher, Roslyn High School, Roslyn Heights, N. Y.
Zubiran, Salvador, M.D., Internal Medicine, Endocrinology. Director, Hospital De Enfermedades de La Nutricion, Mexico D.F., Mexico.

STUDENT MEMBERSHIP

Geller, Leah, Physiology. Student, Hunter College, New York, N. Y.
Nelson, Lawrence Barclay, B.A., Physical Chemistry, New York University, N. Y.
Peterson, Howard Charles, Student, Hunter College, New York, N. Y.

Elected July 15, 1954

SUSTAINING MEMBERSHIP

Barber, Radivoj Ray, M.D., Internal Medicine. Practicing Internist, Plymouth, Mich.
Blass, Gustaf, M.D., Psychology, Senior Psychiatrist. Stamford Hall, Stamford, Conn.
Brewster, Edward Sumner, M.D., Internal Medicine. Private Practice, Danville, Ill.
Levine, Sumner, Ph.D., Biochemistry. Chief, Research Laboratories, Veterans Administration Hospital, East Orange, N.J.

ACTIVE MEMBERSHIP

Abel, Stuart, M.D., Medicine. Assistant Professor, Northwestern University Medical School, Chicago, Ill.
Adelman, Nathan, M.D., Medicine. Private Practice, New York, N.Y.
Adler, Alfred, M.D., Medicine. Medical Director, Richland Hospital, Mansfield, Ohio.
Alerte, Franck C., M.D. Pathology. Chief Resident in Pathology, Providence Hospital, Detroit, Mich.
Allen, James M., M.D., Pediatrics. Private Practice, Passaic, N.J.
Andrews, Sumner C., M.D., Medicine. Private Practice, Boston, Mass.
Avotkins, Randolph V., M.D., Medicine. Redfield State Hospital, Redfield, S.D.
Baba, George R., M.D., Gynecology. Clinical Instructor, University of Southern California, Los Angeles, Calif.
Bachrach, Arthur Julian, Ph.D., Medical Psychology. Director, Division of Clinical and Medical Psychology, University of Virginia, Charlottesville, Va.
Bailey, Frank W., M.D., Biology. Neurosurgeon, Fresno, Calif.
Baker, David, M.D., Pediatrics. Research Fellow, Pediatric Nutrition, University of Pennsylvania, Philadelphia, Pa.
Barber, C. Glenn, M.D., Orthopedic Surgery. Associate Orthopedic Surgeon, Lakeside Hospital, Cleveland, Ohio.
Barnes, Waddell, M.D., Internal Medicine. Clinical Fellow in Medicine, Yale Medical School, New Haven, Conn.
Barta, Frank Rudolph, M.D., Psychiatry. Professor, Chairman, Department of Psychiatry, Creighton University, Omaha, Neb.

Barwise, Constance M., M.D., Psychiatry. Acting Assistant Director, Marcy State Hospital, Marcy, N.Y.

Baum, Felix, M.D., Cancer Research. Consultant in Pulmonary Diseases, St. Mary's Hospital, Orange, N.J.

Baumeister, Carl F., M.D., Internal Medicine. Private Practice, Berwyn, Ill.

Beauregard, Jean-Marie, M.D., Biology. Chief, Department Medicine, Verdun General Hospital, Montreal, P.Q., Canada.

Benteen, Harry, M.D., Surgery. Lecturer, Surgery, University of California, Berkeley, Calif.

Beegel, Paul Milton, M.D., Orthopedic Surgery. Attending Surgeon, Central Maine General Hospital, Lewiston, Maine.

Berglund, Erik, M.D., Biology. Research Associate, Department Physiology, Harvard School of Public Health, Boston, Mass.

Berlin, Louis, M.D., Neurology, Psychiatry. Assistant Professor, Medicine, Cornell University Medical College, New York, N.Y.

Berry, Keehn W., Jr., M.D., Internal Medicine. Instructor in Medicine, Medical College of Alabama, Birmingham, Ala.

Berryman, George Hugh, M.D., Medical Research. Head, Clinical Research, Abbott Laboratories, North Chicago, Ill.

Betcher, Albert M., M.D., Medicine, Physiology. Director, Anesthesiology, Hospital for Joint Diseases, New York, N.Y.

Bine, René, Jr., M.D., Internal Medicine. Private Practice, San Francisco, Calif.

Blatt, Herman, M.D., Bacterial Allergy. Private Practice, Cincinnati, Ohio.

Bleier, Adolph H., M.D., Biology, Medicine. Chief, Department of Dermatology, Chester Hospital, Chester, Pa.

Borrison, Joseph A., M.D., Biology. Senior Surgeon, Allegheny Valley Hospital, Tarentum, Pa.

Boslow, Harold M., M.D., Psychiatry. Director, Patuxtent Institution, Baltimore, Md.

Boudart, Michel, Ph.D., Chemistry. Assistant Professor, Chemical Engineering, Princeton University, Princeton, N.J.

Brodhead, William Francis, M.D., Dynamic Composition, Biochemistry. Private Practice, New York, N.Y.

Brody, Matthew, M.D., Neurology, Psychiatry. Associate Attending Neuropsychiatrist, Jewish Hospital, Brooklyn, N.Y.

Calandra, J. C., M.D., Biochemistry. Professor, Chemistry, Northwestern University, Chicago, Ill.

Case, Robert Brown, M.D., Physiology. Research Associate, Harvard School of Public Health, Boston, Mass.

Chernoff, Hyman Mordecai, M.D., Internal Medicine. Clinical Instructor Medicine, Yale School of Medicine, New Haven, Conn.

Condoulis, George A., M.S., Pharmacology. Graduate Student, Cornell University, New York, N.Y.

Desir, Hermann L., Anthropology. Attache Cultural, Embassy of Haiti, New York, N.Y.

D'Iorio, Antoine, Ph.D., Biochemistry. Assistant Professor, Physiology, University of Montreal, Montreal, Canada.

Ebaugh, Franklin G., Jr., Hematology. Senior Assistant Surgeon, U.S. Public Health Service, Bethesda, Md.

Eisen, Henry, Ph.D., Pharmaceutical Chemistry. Assistant Professor, Pharmacy, St. John's University, Brooklyn, N.Y.

Feigelson, Philip, Ph.D., Biochemistry. Assistant Professor, Biochemistry, Columbia University, New York, N.Y.

Haberman, Jack, M.D., Biology. Practicing Chiropractic Physician, Newark, N.J.

Halsted, James A., M.D., Nutrition. Chief, Gastroenterological Section, V.A. Center, Los Angeles, Calif.

Hedgecock, Loyd W., Ph.D., Infectious Diseases. Assistant Professor, Department of Microbiology, University of Kansas, Kansas City, Mo.

Houston, R. Wayne, D. Eng. Chemical Engineering. Assistant Professor, Chemical Engineering, Columbia University, New York, N.Y.

Hughes, Robert Alexander, M.D., Neurosurgery. Fellow, Neurosurgery, Mayo Foundation, Rochester, Minn.

Kuhn, Paul H., M.D., Medicine. Assistant Professor, Clinical Medicine, New York University, Postgraduate Medical School, New York, N.Y.
Liberson, W. T., M.D., Biology. Chief, EEG. Lab., Veterans Administration Hospital, Northampton, Mass.
Lynch, Dorothy E., Immunology. Chief, Research Technician, Serum Research Laboratory, Mt. Sinai Medical Research Foundation, Chicago, Ill.
Murtaugh, Walter A., M.S., Physics. Chairman, Physics, Providence College, Providence, R.I.
Nagle, Raymond J., D.M.D., Dentistry. Dean, College of Dentistry, New York University, New York, N.Y.
Partenope, Edward A., M.D., Cardiovascular Hemodynamics. Colonia, N.J.
Ruskin, Herman David, M.R.C.P., Cardiovascular Disease. Assistant Professor, Medicine, New York State University Medical School, Brooklyn, N.Y.
Singruen, Elsie, Fermentology. Technical Director, Brewers Yeast Council, Chicago, Ill.
Tardif, Dollard, B.Sc., Biological Chemistry. Scientific Director, Rougier Freres, Montreal, P.Q., Canada.
Teague, Russell E., M.D., Public Health. Secretary of Health, Commonwealth of Pennsylvania, Harrisburg, Pa.
van der Heide, J. Homan, Pharmaceutical Chemicals. Vice President, Fries Bros. Inc., Bloomfield, N.J.
Vazquez, Manuel, Biochemistry. Junior Chemist, Department of Hospitals, City Hospital, New York, N.Y.
Williams, Robert J., Ph.D., Psychology. Assistant Professor, Psychology, Columbia University, New York, N.Y.
Zilversmit, Rolf, B.A., Physiology. Medical Student, New York, N.Y.

Elected August 16, 1954

SUSTAINING MEMBERSHIP

Agnone, Eugene John, M.D., Anesthesiology. Anesthesiologist, Detroit Memorial Hospital, Detroit, Mich.
Beine, William R., M.D., Medicine. Private Practice, Coffeyville, Kansas.
Braunstein, M. M., M.D., Sterility. Sterility Clinic, Jewish General Hospital, Montreal, P.Q., Can.
Brazda, Adolph William, M.D., Cancer Research. Private Practice, Ranger, Texas.
Brown, Royal Lee, M.D., Medicine. Private Practice, Riverside, Calif.
Campbell, Edmund W., M.D., Hematology. Clinical Instructor, Medicine, University of Oregon, Portland, Ore.
Cahoon, Daniel H., M.D., Internal Medicine. Private Practice, Roswell, N.M.
Ciarla, Philomen Peter, M.D., Cancer. Associate Surgeon, Newport Hospital, Newport, R.I.
Citron, Robert R., M.D., Immunology. Staff Physician, Galesburg State Research Hospital, Galesburg, Ill.
Collins, C. L., M.D., Psychology, Medicine. Private Practice, Vallejo, Calif.
Comanduras, Peter D., M.D., Internal Medicine. Associate Professor, George Washington University, Washington, D.C.
Constantine, Joseph E., M.D., Medicine. Director of Obstetrics, Parkway Hospital, New York, N.Y.
Donaldson, James Bowie, M.D., Cardiology. Assistant Professor, Medicine, Hahnemann Medical College, Philadelphia, Pa.
Dougherty, John H., M.D., Prostatic Cancer. Genito-urinary Surgeon, Private Practice, Knoxville, Tenn.
Dozoretz, Louis, M.D., Psychiatry. Superyising Psychiatrist, Buffalo State Hospital, Buffalo, N.Y.
Elovzin, Manning, M.D., Internal Medicine. Senior Physician, Health Department, Receiving Hospital, Detroit, Mich.
Guthrie, Donald, M.D., Medicine. Chief Surgeon, Guthrie Clinic and Robert Packer Hospital, Sayre, Pa.

ACTIVE MEMBERSHIP

Aikawa, Jerry Kazuo, M.D., Internal Medicine. Assistant Professor, Medicine, University of Colorado, Denver, Colo.
Alikes, George C., M.D., Internal Medicine. Physician, Brooklyn, N.Y.
Amadeo, Jose A., M.D., Cardiology. Physician, Ponce, P.R.
Armstrong, Charles D., M.D., Internal Medicine. Menlo Medical Center, Menlo Park, Calif.
Arnold, James H., M.D., Biology, Anthropology. Ch. Warren Co., Lebanon, Ohio.
Ashton, Paul M., M.D., Medicine. Private Practice, Springfield, Mass.
Arrowsmith, William R., M.D., Medicine, Hematology. Head, Dept. Medicine, Ochsner Clinic, New Orleans, La.
Axelrod, Walter L., M.D., Medicine. Private Practice, Van Nuys, Calif.
Ballard, V.B., M.D., Medicine. Private Practice, Kansas City, Mo.
Bardos, Thomas J., Ph.D., Organic Chemistry. Research Chemist, Armour Laboratories, Chicago, Ill.
Barringer, Phil L., M.D., Medicine. Chief, Surgery and Staff, Bertie County Memorial Hospital, Windsor, N.C.
Bartels, Carl C., M.D., Internal Medicine. Lahey Clinic, Boston, Mass.
Barwasser, Norbert Clement, M.D., Dermatology, Mycology. Dermatologist, Moline, Ill.
Bassett, Robert Champion, M.D., Neurosurgery. Associate Professor, Surgery, University of Michigan, Ann Arbor, Mich.
Basso, Joseph C., M.D., Medicine. Kenmore Hospital, Boston, Mass.
Beeman, C. B., M.D., Internal Medicine. Private Practice, Grand Rapids, Mich.
Bellville, J. Weldon, M.D., Anesthesiology. Resident Anesthesiologist, New York Hospital, New York, N.Y.
Benes, D. M., M.D., Medicine. Private Practice, Haxtun, Col.
Benson, Carl F., M.D., Biology, Psychology. Private Practice, Baltimore, Md.
Bentley, Ben A., B.S., Pharmaceuticals. Ciba Pharmaceutical Products Inc., Summit, N.J.
Bergen, Otto M., M.D., Internal Medicine. Instructor, Medicine, New York Medical College, New York, N.Y.
Bergenstal, Delbert M., M.D., Internal Medicine, Endocrinology. Assistant Professor, Department of Medicine, University of Chicago, Chicago, Ill.
Berlinguet, Louis, D.Sc., Amino Acids. Professor, Chemistry, Laval University, Quebec, P.Q., Can.
Berman, Leo, M.D., Psychoanalysis. Instructor, Harvard Medical School, Boston, Mass.
Berman, Reuben, M.D., Medicine. Private Practice, Minneapolis, Minn.
Bernard, Jean, Hematology. Professor, Department of Medicine, University of Paris, Paris, France.
Bernstein, Leon L., M.D., Neurological Surgery. Private Practice, Youngstown, Ohio.
Bertrand, John J., M.D., Medical Physics. Director, Department Medical Physics, St. Mary's Hospital, San Francisco, Calif.
Bichacoff, Billie Delores, M.D., Medicine. Private Practice, Fort Wayne, Ind.
Bigelow, Nolton H., M.D., Pathology. Associate Professor, Pathology, Albany Medical College, Albany, N.Y.
Black, Roger Lewis, M.D., Internal Medicine. Assistant in Medicine, Johns Hopkins University, Baltimore, Md.
Blier, Julius S., M.D., Internal Medicine. Private Practice, New York, N.Y.
Bliss, Eugene L., M.D., Psychiatry. Assistant Clinical Professor, Psychiatry, Yale University, New Haven, Conn.
Bloch, Winston N., M.D., Medicine. Private Practice, Louisville, Ky.
Blount, Robert Eames, M.D., Gynecology. Private Practice, Leesburg, Fla.
Bortz, Donald W., M.D., Internal Medicine. Internist, Greensburg, Pa.
Bomze, Edward J., M.D., Medicine. Chairman, Department of Obstetrics and Gynecology, Methodist Hospital of Southern California, Los Angeles, Calif.
Bosworth, Robinson, M.D., Mycology. Superintendent and Medical Director, Rock Island County Tuberculosis Sanatorium, Rock Island, Ill.
Bowers, F. Clyde, M.D., Medicine. Private Practice, Mendham, N.J.
Boyer, Sam, Jr., Cardiovascular Disease. Private Practice, Duluth, Minn.

Bramigk, Fritz W., M.D., Medicine. Private Practice, Detroit, Mich.
Brason, F. Wells, M.D., Basic Science, Medicine. Pathologist, Brooks Memorial Hospital, Dunkirk, N.Y.
Brampton, George Firth, M.D., Biology, Anthropology. Private Practice, Salterville Springs, N.Y.
Braswell, Leon Melvin, M.D., Medicine, Private Practice, Lynchburg, Va.
Breneman, Gerald M., M.D., Cardiology. Assistant, Department of Medicine, Henry Ford Hospital, Detroit, Mich.
Brenner, Louis O., M.D., Medicine. Private Practice, Harrisburg, Pa.
Brieger, H., M.D., Industrial Medicine. Professor, Jefferson Medical College, Philadelphia, Pa.
Briskier, Arthur A., M.D., Medicine, Cardiology. Private Practice, New York, N.Y.
Brooks, Nathaniel Preston, M.D., Medicine. Private Practice, Croton-on-Hudson, N.Y.
Brooks, Walter A., M.D., Medicine. Private Practice, Russellville, Ark.
Brown, Archie E., M.D., Arthritis. Private Practice, Indianapolis, Ind.
Brown, Hugh James, M.D., Medicine, Surgery. Private Practice, Tillamook, Ore.
Brown, J. Edward, M.D., Medicine, Anthropology. Medical Director, Bristol General Hospital, Bristol, Pa.
Brown, Lawrence Greeley, M.D., Physiology, Biochemistry. Private Practice, Elizabeth, N.J.
Brown, R. Gordon, M.D., Internal Medicine. Associate Professor, Medicine, University of Illinois, Chicago, Ill.
Brown, Robert J., III, M.D., Organic Chemistry. Private Practice, Norfolk, Va.
Brown, William Tibor, M.D., Ophthalmology. Ophthalmologist, New York, N.Y.
Browning, George L., M.D., Internal Medicine. Private Practice, Sacramento, Calif.
Brundage, Robert D., M.D., Internal Medicine. Ypsilanti, Mich.
Buckley, Nancy M., M.D., Physiology. Assistant Professor, Ohio State University, Columbus, Ohio.
Buckley, George Finlay, M.D., Medicine. Private Practice, Stouffville, Ont., Can.
Bukantz, Samuel Charles, M.D., Internal Medicine, Allergy. Associate Professor, Clinical Medicine, Washington University, St. Louis, Mo.
Bunting, John J., M.D., Internal Medicine. Private Practice, Houston, Texas.
Burba, William Howard, M.D., Psychiatry, Psychology. Senior Resident Physician in Neuropsychiatry, Walter Reed Army Hospital, Washington, D.C.
Burian, Hermann M., M.D., Ophthalmology. Professor, College of Medicine, State University of Iowa City, Iowa.
Burrows, E. G., M.D., Medicine. Private Practice, Inglewood, Calif.
Cacciatore, Thomas J., M.D., Cardiology. Physician, Huntington Hospital, Huntington Station, N.Y.
Calkius, Evan, M.D., Internal Medicine. Instructor in Medicine, Harvard Medical School, Boston, Mass.
Call, Lloyd S., M.D., Internal Medicine. Private Practice, Pocatello, Idaho.
Cameron, Douglas George, M.D., Clinical Investigation. Assistant Director, McGill University Clinic, Montreal General Hospital, Montreal, P.Q., Can.
Cammer, Leonard, M.D., Psychology. Associate Clinical Professor, New York Medical College, New York, N.Y.
Cantero, Antonio, M.D., Cancer Research. Research Director, Montreal Cancer Institute, Notre Dame Hospital, Montreal, P.Q., Can.
Cantor, Aaron S., M.D., Chest Diseases. Chief, Cardiovascular Diseases, Hahnemann Hospital, Scranton, Pa.
Caplan, Max, M.D., Gastroenterology. Private Practice, Meriden, Conn.
Carmichael, Donald M., M.D., Psychiatry. Director, After Care Clinics, New York Department of Mental Hygiene, New York, N.Y.
Carnes, Harry E., M.D., Clinical Investigation. Parke, Davis and Company, Detroit, Mich.
Carpento, D. D., M.D., Psychology, Medicine. Vice Chairman, St. Joseph's Hospital, Sarnia, Ont., Can.
Carter, Howard, M.D., Pharmacology. Private Practice, Browning, Mo.
Cauldwell, Earl W., M.D., Medicine. Pathologist, Director of Laboratories, Beloit Municipal Hospital, Beloit, Wis.
Chapple, Charles C., M.D., Pediatrics. Children's Hospital of Philadelphia, Philadelphia, Pa.

Chevalley, Jacqueline E., M.D., Endocrinology. Private Practice, New York, N.Y.
Chezak, Henry Harold, M.D., Biology. Private Practice, New York, N.Y.
Ching, Ellsworth Y., M.D., Medicine. Private Practice, Allston, Mass.
Chinn, May E., M.D., Cancer. Assoc. Attending Strang Cancer Prevention Clinic, Memorial Hospital, New York, N.Y.
Chiu, Gin-chi, M.D., Cardiology. Physician, The Lilly Research Laboratories, Indianapolis, Ind.
Chou, Tzu Pei, M.D., Medicine. Private Practice, New York, N.Y.
Chu, C. L., M.D., Internal Medicine. Assistant Physician, State Sanatorium for Tuberculosis, Sanator, S.D.
Chu, Ling Sun, M.D., Medicine. Instructor in Medicine, State University of New York, New York, N.Y.
Claman, Leoni Neumann, M.D., Allergy. Private Practice, New York, N.Y.
Clapper, Muir, M.D., Internal Medicine. Professor, Medicine, Wayne University, Detroit, Mich.
Clark, Arch B., M.D., Immunology. Private Practice, McKee, Ky.
Clark, John A., M.D., Medicine. Private Practice, Gilroy, Calif.
Clark, Louise Leland, M.D., Biology. Private Practice, Chester, Va.
Clark, Ronald E., M.D., Internal Medicine. Private Practice, Ann Arbor, Mich.
Clark, W. Kenneth, M.D., Cancer. Assistant Medical and Scientific Director, American Cancer Society, New York, N.Y.
Clarke, Charles Walter, Jr., M.D., Internal Medicine. Clinical Assistant, Peripheral Vascular Clinic, St. Luke's Hospital, New York, N.Y.
Cohen, Flossie, M.D., Pediatrics. Children's Hospital of Michigan, Detroit, Mich.
Cohen, Sheldon G., M.D., Immunology. Research Associate, Department of Biology, Wilkes College, Wilkes-Barre, Pa.
Cohn, Morris A., M.D., Medicine. Private Practice, Monticello, N.Y.
Cohnberg, Rosellen Elaine, M.D., Medicine. Pediatrician, Private Practice, Monett, Mo.
Collins, Grover C., M.D., Medicine. Private Practice, Palatka, Fla.
Collins, Margaret C., M.D., Pathology. Temple University Hospital, Philadelphia, Pa.
Colodny, Paul C., M.A., Physical Chemistry. Research Chemist, Aeronautical Research Laboratory, Wright-Patterson A.F.B., Ohio.
Cone, Theodore Stroud, M.D., Internal Medicine. Private Practice, Tuscaloosa, Ala.
Conner, Eugene H., M.D., Pharmacology, Physiology. Director, Anesthesiology, Philadelphia General Hospital, Philadelphia, Pa.
Cook, Norman Richard, M.D., Biology, Psychology. Private Practice, Richmond, Ind.
Cooper, William M., M.D., Medicine, Hematology. Instructor, Medicine, University of Pittsburgh, Pittsburgh, Pa.
Cooperberg, A. Arthur, M.D., Hematology. Hematologist, Jewish General Hospital, Montreal, P.Q., Can.
Cotsonas, Nicholas John, Jr., M.D., Medicine. Assistant Professor of Medicine, University of Illinois, Chicago, Ill.
Cotton, John M., M.D., Medicine, Psychiatry. Director of Psychiatry, St. Luke's Hospital, New York, N.Y.
Craddock, Charles G., Jr., M.D., Medicine, Hematology. Associate Professor of Medicine, University of California, Los Angeles, Calif.
Crandall, Charles Eben, Jr., M.D., Medicine. Clinical Fellow in Medicine, College of Physicians and Surgeons, Columbia University, New York, N.Y.
Cron, Cyril M., M.D., Medicine, Surgery. Private Practice, Miami, Ariz.
Dart, Dorothy, M.D., Physics, Chemistry. Private Practice, Lansing, Mich.
Daversa, Joseph J., M.D., Cancer. Radiologist, Good Samaritan Hospital, West Palm Beach, Fla.
Decary, Charles, M.D., Biology. Chief of Staff, St. Joseph's Hospital, Lachine, P.Q., Can.
De Groot, H. B. Struivig, M.D., Surgery. General Hospital, Regina, Canada.
DeLamater, James N., M.D., Parasitology. Clinical Professor of Medicine, University Southern California, Los Angeles, Calif.
Dewlett, Hal Joseph, M.D., Biology. Medical Director, Woodlawn Tuberculosis Hospital, Dallas, Texas.

Donnelly, John, M.D., Psychiatry. Clinical Director, Institute of Living, Hartford, Conn.
Dorain, Paul B., Ph.D., Physical Chemistry. Research Associate, Institute for Nuclear Studies, University of Chicago, Chicago, Ill.
Doupe, Joseph, M.D., Physiology. Professor of Physiology and Medical Research, University of Manitoba, Winnipeg, Manitoba, Can.
Duquette, Leo Henry, M.D., General Science. Private Practice, Warwick, R.I.
Dworken, Harvey J., M.D., Internal Medicine. Private Practice, Cleveland, Ohio.
Eckart, DeMerle E., M.D., Biology, Psychology. Chief of Medical Staff, Grace Hospital, Hutchinson, Kan.
Einhorn, William Lawrence, M.D., Biology. Assistant Visiting Physician, Queens General Hospital, Jamaica, N.Y.
Elias, John C., M.D., Medicine. Physician, Morris, Manitoba, Can.
Flynn, John E., Ph.D., Biology. Biologist, Scientific Department, Office of Naval Research, New York, N.Y.
Foley, George Edward, D.Sc., Medical Microbiology. Chief, Laboratories of Microbiology, Children's Cancer Research Foundation, Boston, Mass.
Fryth, Peter W., B.A., Medicinal Research. Research Associate, Biological and Chemical Research Section, Lederle Laboratories Division, American Cyanamid Company, Pearl River, N.Y.
Goldburg, Morton E., B.S., Pharmacology. Philadelphia College of Pharmacy, Philadelphia, Pa.
Grant, Dwinell, BFA, General Science. Vice President, Sturgis-Grant Productions Inc., New York, N.Y.
Hoch, Frederic L., M.D., Biochemistry, Biophysics. Research Associate in Medicine, Harvard Medical School, Cambridge, Mass.
King, Louis D., Ph.D., Pharmacy. Assistant Professor of Pharmacy, Rutgers University, Newark, N.J.
Kling, Arthur, B.S., Neurophysiology. Medical Research Assistant, Northwestern University, Chicago, Ill.
Ling, Ji-toong, M.D., Radiobiology. Instructor in Radiology, University of Louisville, Louisville, Ky.
Markowitz, Abraham, Ph.D., Medical Microbiology, Immunology. Assistant Professor of Bacteriology, San Diego State College, San Diego Calif.
Martinez-Alvarez, Antonio, M.D., Medicine, Climatology. Santurce, Puerto Rico.
Newman, Stanley, M.D., Internal Medicine. Radioisotope Clinic, Walter Reed Army Hospital, Washington, D.C.
Resnik, Robert A., Ph.D., Chemistry. Chief, Section of Ophthalmic Chemistry, National Institute of Neurological Diseases and Blindness, Bethesda, Md.
Shields, Arthur J., M.D., Medicine, Surgery. Industrial Surgeon, Chicago, Ill.
Sobel, Edna H., M.D., Pediatric Endocrinology. Research Associate, Children's Cancer Research Foundation, Boston, Mass.
Sprehn, George W., M.D., Medicine. Private Practice, Washington, D.C.
Strawinski, Raymond John, Ph.D., Microbiology. Assistant Professor, Louisiana State University, Baton Rouge, La.
Tabachnick, Joseph, Ph.D., Cell Physiology. Research Biochemist, Albert Einstein Medical Center, Philadelphia, Pa.
Thompson, Howard T., M.D., Urology. Physician, Rochester, N.Y.
Ultmann, John Ernest, M.D., Hematology, Oncology. Trainee, National Cancer Institute, Assistant of Medicine, New York Hospital, New York, N.Y.
Wuggatzer, Walter L., Ph.D., Pharmaceutical Chemistry. Assistant Professor of Pharmacy, Rutgers University, Newark, N.J.

STUDENT MEMBERSHIP

Rau, Eric, B.A., Physical Chemistry. Student, New York University, New York, N.Y.

Elected September 23, 1954

LIFE MEMBERSHIP

Esposito, Neil, M.D., Medicine. Private Practice, Minonk, Ill.

SUSTAINING MEMBERSHIP

Bien, Charles W., M.D., Physiology. Staff, Department of Internal Medicine, Kaiser Foundation Hospital, Vallejo, Calif.
Dickson, Douglas D., M.D., Biology. Private Practice, Oakland, Calif.
Dight, E. K., M.D., Endometriosis. Columbus Hospital, Seattle, Wash.
Dixon, V. L., M.D., Medicine. Private Practice, Kansas City, Mo.
Dobosiewicz, Arthur L., M.D., Biology. Private Practice, Nelsonville, Ohio.
Dowd, George C., M.D., Geriatric Medicine. Chairman, National Advisory Committee on Industrial Employment of Older People, Worcester, Mass.
Edinger, Ladislav, M.D., Biology. Private Practice, New York, N.Y.
Ehrlich, Edward N., M.D., Pathology. Medical Officer, U.S. Navy Medical Corp.
Eisaman, Jack L., M.D., Biology. Consultant, Cardiovascular Diseases, Caylor-Nickel Clinic and Clinic Hospital, Bluffton, Ind.
Ernst, H. Oliver, M.D., Medicine. Visiting Surgeon, Touro Infirmary, New Orleans, La.
Faraçi, Charles J., M.D., Medicine. All Souls Hospital, Morristown, N.J.
Feinstein, Bertram, M.D., Neurosurgery. Private Practice, San Francisco, Calif.

ACTIVE MEMBERSHIP

Adams, Chester H., M.D., Medicine. Private Practice, Flint, Mich.
Andrews, Lale C., Electronic Computers. Consultant on High Temperature Piping, M.W. Kellogg Company, New York, N.Y.
Barawil, Wadi A., M.D., Pathology. Instructor, Harvard Medical School, Boston, Mass.
Bardawill, Charles J., M.D., Biochemical Research. Clinical Teacher in Medicine, University of Toronto, Toronto, Can.
Berger, Samuel S., M.D., Internal Medicine. Private Practice, Cleveland, Ohio.
Bianchine, Joseph Raymond, B.S., Pharmacology. Research Fellow in Pharmacology, Albany Medical College, Albany, N.Y.
Bibring, Grete L., M.D., Psychiatry. Head, Department Psychiatry, Beth Israel Hospital, Boston, Mass.
Bischoff, Harold W., M.D., Immunology. Private Practice, Dimmitt, Texas.
Bishop, George C., M.D., Medicine. Good Samaritan Hospital, Cincinnati, Ohio.
Blank, Philip, M.D., Allergy. Private Practice, Pittsburgh, Pa.
Boag, T. J., Psychiatry. Lecturer, Department, Psychiatry, McGill University, Montreal, P.Q., Can.
Bocking, Douglas, M.D., Rheumatic Diseases. Instructor, University of Western Ontario, London, Ont., Can.
Boeck, Virgil H. F., M.D., Internal Medicine. Associate Attending Physician, Millard Fillmore Hospital, Buffalo, N.Y.
Bowers, Roy Anderson, Ph.D., Pharmacy. Dean, Professor, Pharmacy, Rutgers University, Newark, N.J.
Boyd, Thomas A., M.D., Medicine. Private Practice, Springfield, Pa.
Brachman, Philip S., M.D., Public Health. U. S. Public Health Service, Philadelphia, Pa.
Breitbart, George Jay, M.D., Psychiatry. Private Practice, New York, N.Y.
Brennen, William H., M.D., Medicine. Chief, Sunnyside Clinic, Sunnyside, Wash.
Brodey, Marvin, M.D., Mycology, Dermatology. Assistant Dermatologist, Columbia-Presbyterian Medical Center, New York, N.Y.
Brodie, Marvin, M.D., Medicine. Resident Physician, Department, Medicine, Sinai Hospital, Detroit, Mich.
Brofman, Bernard L., M.D., Cardiology. Director, Cardiovascular Research, Mt. Sinai Hospital, Cleveland, Ohio.
Brown, Ethan Allan, M.D., Internal Medicine. Associate Professor, Pediatrics, Tufts College, Boston, Mass.
Brown, Ian A., M.D., Medicine, Neurology. Assistant Professor, University of Minnesota, Minneapolis, Minn.
Brown, Merle J., M.D., Surgery. Private Practice, Davenport, Iowa.
Brown, Robert Whitcomb, M.D., Neurology. Clinical Director, Western State Hospital, Fort Steilacoom, Wash.
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